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MACHINE DESIGN

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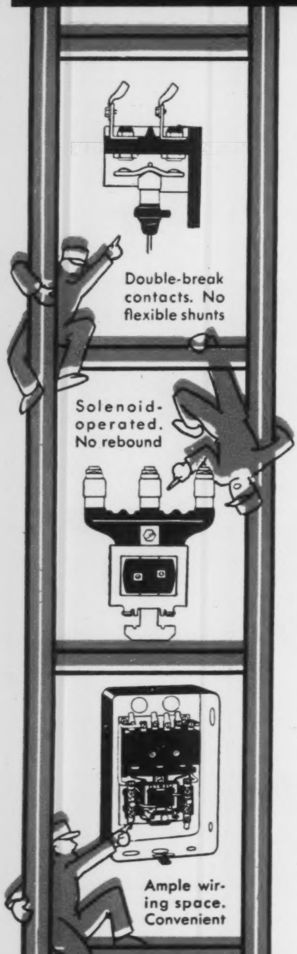
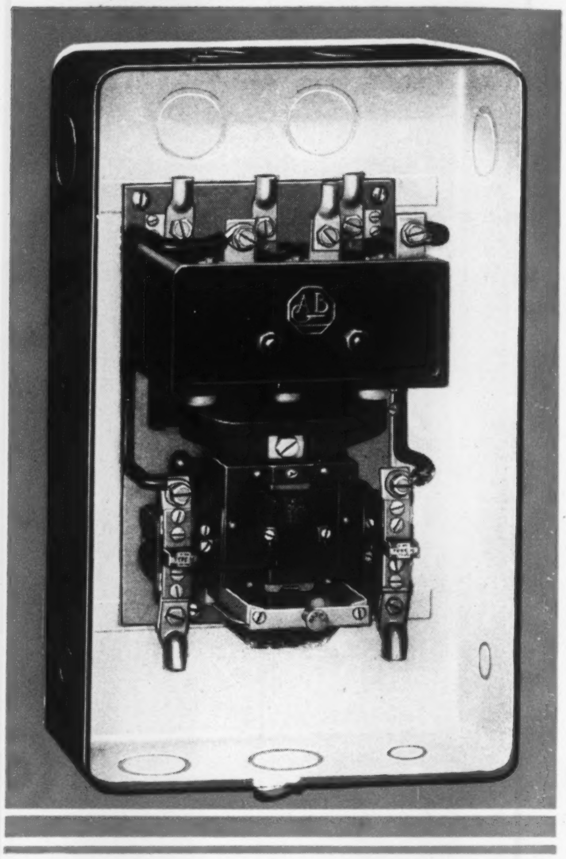
ENGINEERING—PRODUCTION—SALES

Greater Switching Capacity . . . Smaller Size . . Unequaled Simplicity


Double-break contacts. No flexible shunts
Solenoid-operated. No rebound
Ample wiring space. Convenient
No molded or slate panels.
No concealed or back panel wiring

That's the

NEW BULLETIN 709 SOLENOID STARTER



It's in a class by itself! All engineers who have seen the new line marvel that such tremendous switching capacity has been attained in a switch so compact. Ten times maximum rated current at listed voltage is easily disrupted. This has been accomplished by using solenoid-operated mechanisms.

There are no flexible shunts and the double-break silver alloy contacts require no maintenance. The straight-line motion prevents accidental closure of switch from jars and jolts. And pick-up and drop-out voltages are low: pick-up 70%; drop-out 50% of line voltage.

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The white Reflexo-finish of cabinet interiors reflects light and facilitates wiring in dark corners.

The symmetry of design and quality appearance of the Bulletin 709 line are assets to any installation and are especially valuable to resale manufacturers. Send for bulletin, today!

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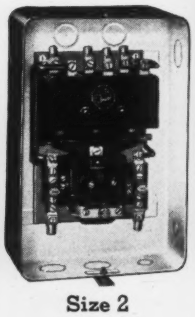

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ALLEN-BRADLEY
BULLETIN 709 SOLENOID STARTER

MACHINE DESIGN

EDITOR
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VOLUME VI DECEMBER, 1934 NUMBER 12

CONTENTS

Page
REACHING THE LIMITS IN BEARING PERFORMANCE . . . 15
By H. B. Dexter
SCANNING THE FIELD FOR IDEAS 20
SECURING CORROSION RESISTANCE AT LOW COST WITH CLAD SHEETS 22
By Allen F. Clark
OVERCOMING FATIGUE OF SHAFTS AT PRESS-FITTED UNITS 25
By R. E. Peterson and A. M. Wahl
AUXILIARY DEVICES CONTROL SUCCESS OF HYDRAULICS . 28
By John S. Carpenter
NEW DESIGNS DEMAND IMPROVED STEELS 31
By Edwin F. Cone
MEETING SPECIAL CONDITIONS IN CONVEYORS 35
By E. Arentzen
NEW MACHINES INDICATE DESIGN TRENDS 37
DESIGN FEATURES IN NEW MACHINES 38
DEVELOPMENT AND DESIGN STAND BEST CHANCE IN SUBNORMAL PERIODS (EDITORIAL) 40
PROFESSIONAL VIEWPOINTS 41
MEN OF MACHINES 43
OBITUARIES 44
ASSETS TO A BOOKCASE 45
NOTEWORTHY PATENTS 46
HOW IS BUSINESS? 50
TOPICS 52
NEW MATERIALS AND PARTS 58
MANUFACTURERS' PUBLICATIONS 70
RESEARCH PUBLICATIONS 71
BUSINESS ANNOUNCEMENTS AND SALES BRIEFS 73
CALENDAR OF MEETINGS AND EXPOSITIONS 12

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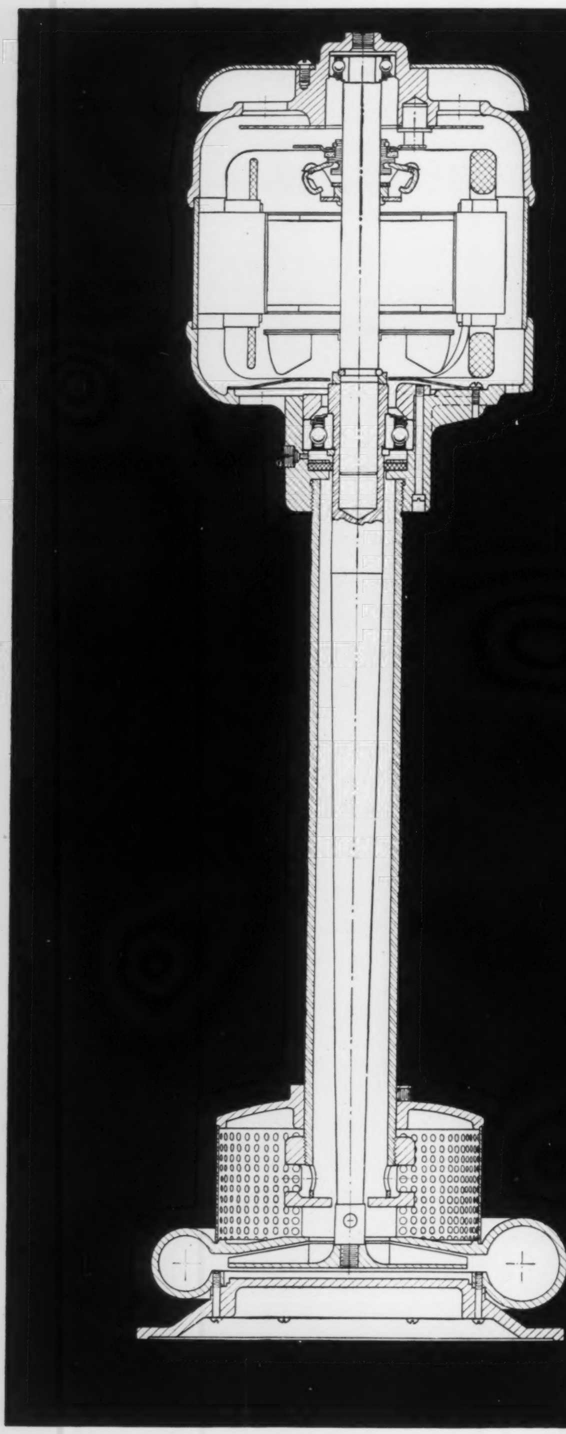

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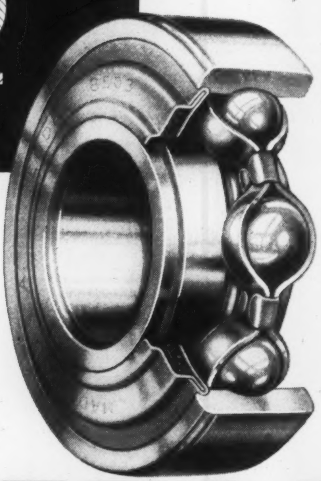

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NEW DEPARTURE

BALL BEARINGS

ITEMIZED INDEX

Classified for Convenience when
Studying Specific Design Problems

Design Calculations:

Shrink and press fits, Edit. 41L, 42

Design Problems:

Bearings, journal, applying, Edit. 15, 16, 17, 18, 19
Conveying, around corners, Edit. 35, 36
Corrosion, resisting, Edit. 22, 23, 24
Fatigue, overcoming, Edit. 25, 26, 27, 67L, 68R
Hydraulic, utilizing, Edit. 28, 29, 30
Materials, separating, Edit. 21R
Performance, determining, Edit. 20
Press fits, developing, Edit. 25, 26, 27, 67L, 68R
Safety, insuring, Edit. 48R
Shrink and press fits, calculating, Edit. 41L, 42
Steels, high tensile, applying, Edit. 31, 32, 33, 34, 69L

Finishes:

Aluminum paint, Edit. 62L
Electrodeposited, Edit. 21R

Materials:

Alloys (Hard-Facing), Edit. 60; Adv. 69R
Alloys (Nickel), Edit. 22, 23, 24, 29L, 31, 32, 35R, 36L
Alloys (Steel), Edit. 19R, 22, 23, 24, 31, 32, 33, 34, 35R, 69L
Aluminum, Edit. 21R
Babbitt, Edit. 19
Brass, Edit. 19, 28R
Bronze, Edit. 16R, 17R, 18, 19, 28R
Copper, Edit. 19, 28R
Molybdenum, Edit. 33R, 34R; Adv. 9
Rubber, Edit. 29R, 47, 48L
Steel, Edit. 16R, 18L, 19, 52R; Adv. 14, 59
Steel (Metal-Clad), Edit. 22, 23, 24

Mechanisms:

Braking, Edit. 56L
Clutch, Edit. 56L
Feeding, Edit. 46R, 47L
Photographic, Edit. 46
Refrigerating, Edit. 20R, 21L
Scotch yoke, Edit. 41
Valve regulating, Edit. 28R, 30L
Vibration dampening, Edit. 47R, 48L

Organization and Equipment:

Engineering department, Adv. 67R, 68L
Markets, developing, Edit. 66R, 67L
Patent law and patent activity, Edit. 54L
Research and invention, Edit. 54

Parts:

Bearings, Edit. 15, 16, 17, 18, 19, 60R; Adv. 6, 63, 64L, 74, 76
Brakes, Edit. 58R, 60L
Cast parts, Edit. 19L, 28R, 45
Compressors, Edit. 62
Controls (Electrical), Edit. 20R, 62R; Adv. 2, 61
Conveyors, Edit. 35, 36
Couplings, Edit. 30R
Drives, Edit. 35R, 36L, 47, 58; Adv. 3, 13, 49, 51, 53, 57, 65, 66L, 70L
Electronic equipment, Edit. 56L
Fastenings, Edit. 64R
Filters, Edit. 58
Gears, Edit. 29L
Hydraulic equipment, Edit. 28, 29, 30
Lubrication and lubricating equipment, Edit. 16, 17, 18, 19
Motors (See also under Drives), Edit. 20R, 30L; Adv. 8, 11, 55
Packing glands and packing, Edit. 29R; Adv. 4
Pumps, Edit. 18, 29L, 64R; Adv. 68L, 70L, 72L
Sheets, Edit. 22, 23, 24
Shims, Adv. 66L
Springs, Edit. 36, 47L; Adv. 10
Turbines, Edit. 29R, 30L
Universal joints, Edit. 35R, 36L
Valves, Edit. 21L, 48L
Welded parts and equipment, Edit. 24L, 52L, 56L, 60R, 62, 64R, 66L; Adv. 63, 75

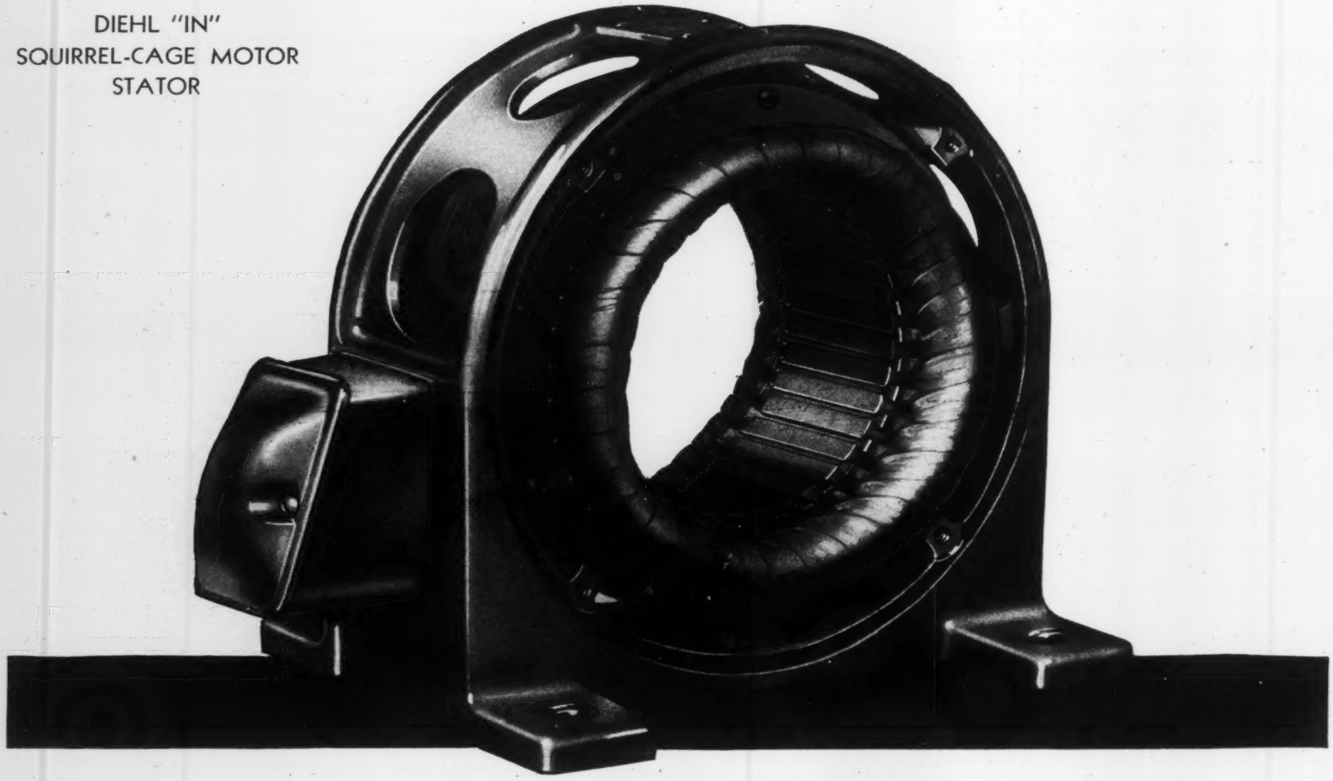
Principles:

Centrifugal, Edit. 18R
Hydraulics, Edit. 28, 29, 30, 36L
Vacuum, Edit. 46

Standardization:

Pressure and vacuum gages, Edit. 52R, 54L

Key: Edit., Editorial Pages; Adv., Advertising Pages; R, Right hand column; L, Left hand column



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SQUIRREL-CAGE MOTOR
STATOR

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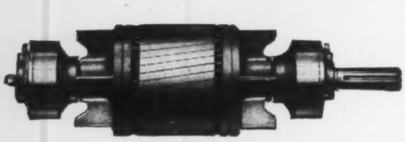

Sleeve Bearing Rotor, showing heavy duty shaft with thrust collars and rugged cast iron blowers that are shrunk in position.

Ball Bearing Rotor, showing cartridge type bearing housing that permits removal of rotor without disturbing ball bearings or exposing them to dust and grit.

Each individual coil of the stator, for example, is completely encased in varnished cambric, giving considerably more insulation than other motors that are ordinarily insulated only between phases in this manner. Entire winding is thoroughly impregnated and proofed against water, oil and even mild chemicals. Completed stator winding is further treated with a special compound giving a hard "glass-like" surface. This prevents heavy accumulation of dust and dirt which might otherwise impair ventilation, cause the motor to overheat, and thereby shorten its life.

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Built to N. E. M. A. Standards, these motors have excellent electrical characteristics, ample overload capacity and high starting torque. Sizes from ¼ to 25 HP. with either oil-ring sleeve bearings or cartridge type ball bearings, are available for immediate shipment from warehouse stocks. Unusual shaft extensions, bearings and mountings can be furnished quickly to suit any special requirement.

Diehl engineers, backed by a half century of experience in serving leading machinery manufacturers and industrial plants, will gladly assist you in selecting the right motor for the job. Diehl motors cover the entire range from fractional to 50 HP., A. C. and D. C. Descriptive Bulletins will be sent on request.

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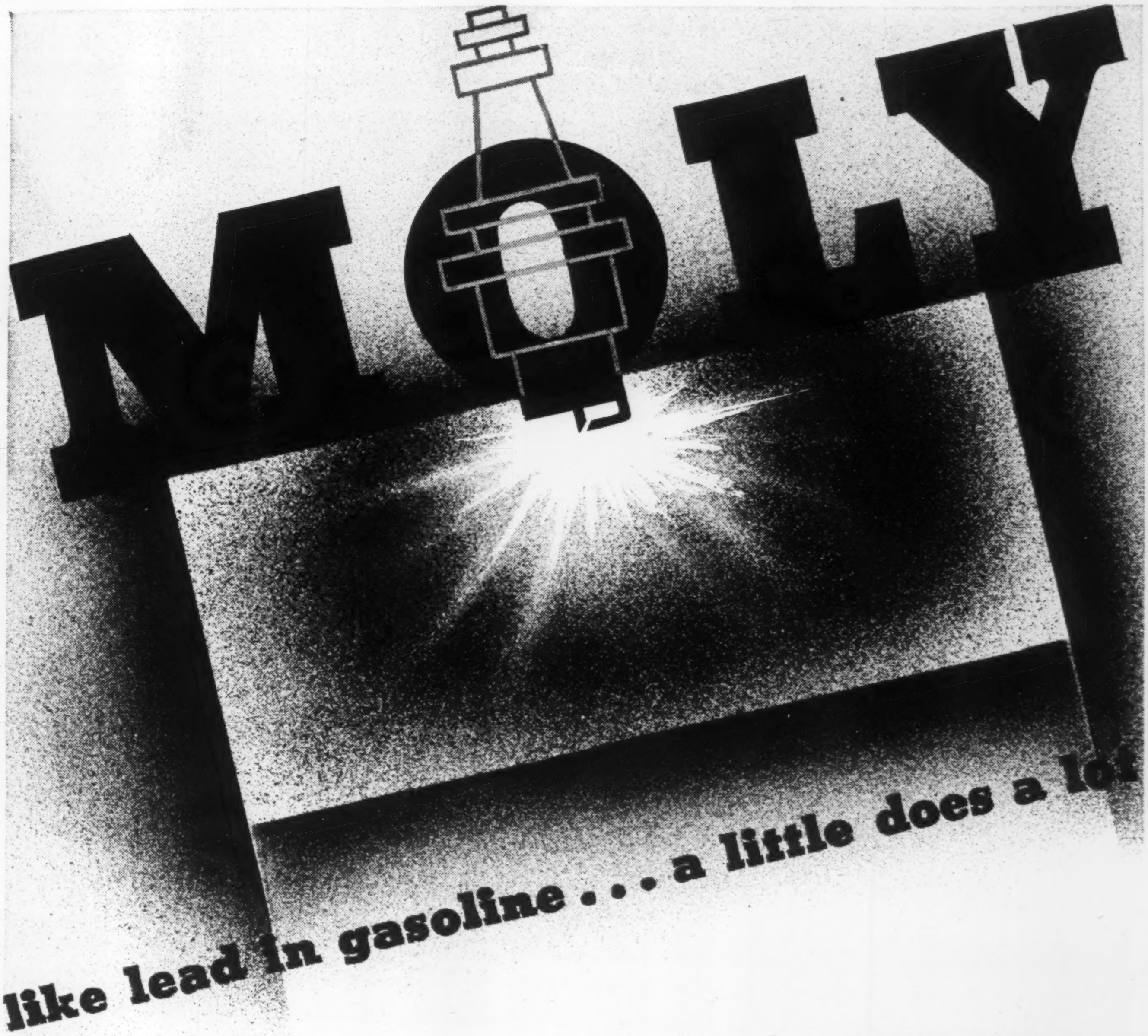
DIEHL MOTORS

DIEHL MANUFACTURING COMPANY, Electrical Division of THE SINGER MANUFACTURING COMPANY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like lead in gasoline . . . a little does a lot

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"The Moly Matrix" is our new house organ, planned to help executives and engineers keep informed of Molybdenum's progress. A simple request puts you on our mailing list. A further request brings you either or both of these new books: *"Molybdenum in* 1934" and *"Molybdenum in Cast Iron*—1934 *Supplement."* And our metallurgists and experimental laboratory in Detroit offer ready assistance toward solving any alloy problems you may have. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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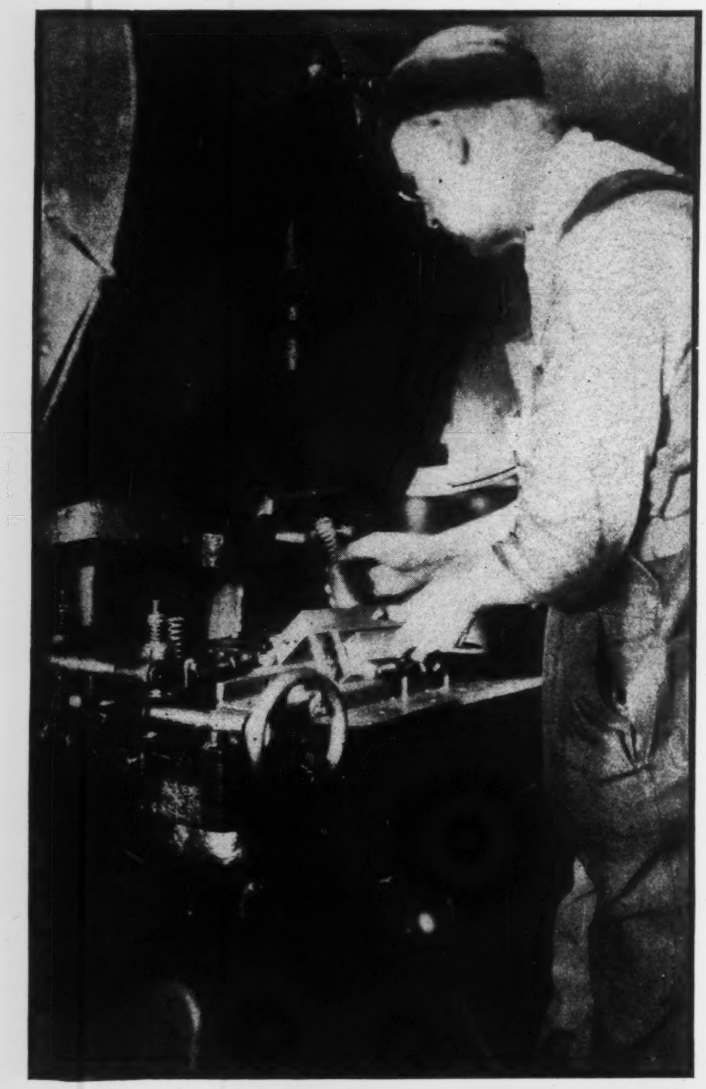
CLIMAX Mo-lyb-den-um

SOLVING UNUSUAL SPRING APPLICATIONS



$$n = \frac{1}{\frac{S_o}{S_y} + \frac{S_v}{S_e}}$$

WITH springs playing a vital part in the operation of most machinery—it is essential that their design be given the utmost care and attention. This applies particularly where special or unusual conditions exist—and where new and untried service is called for. In such instances, formulae, to arrive at a working hypothesis without error, must be based not alone on stress, torsion and other set conditions of operation—but, also, on such important factors as the tensile and fatigue properties of the material used. The thorough familiarity of American Steel & Wire Company technicians with the structural forms of metals—and the application of these metals to spring design—has played an important part in the successful development and use of springs.

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CALENDAR OF MEETINGS AND EXPOSITIONS

Jan. 5-12—

National Automobile Show.

Annual exhibitions to be held at Grand Central Palace, New York.

Jan. 7—

Society of Automotive Engineers.

Thirtieth anniversary dinner to be held at Hotel Commodore, New York. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary of the society.

Jan. 10-12—

American Engineering council.

Annual meeting to be held at Washington hotel, Washington. F. M. Feiker, 744 Jackson place, Washington, is executive secretary of the council.

Jan. 14—

National Association of Bottling Machinery Manufacturers.

Annual meeting to be held at Hotel Statler, Buffalo. Louis B. Montfort, 218 Munsey building, Washington, is secretary of the manufacturers association.

Jan. 14-18—

Society of Automotive Engineers.

Annual meeting to be held at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary of the society.

Jan. 18-26—

National Motor Boat Show.

Annual exhibition of boats, motors and equipment will be held at Grand Central Palace, New York, under the sponsorship of National Association of Boat and Engine Manufacturers. Ira Hand, 420 Lexington avenue, New York, is secretary of the association.

Jan. 22-25—

American Institute of Electrical Engineers.

Annual winter meeting to be held at Engineering Societies building, New York. H. H. Henline, 33 West Thirty-ninth street, New York, is secretary of the institute.

Feb. 17-22—

American Ceramic society.

Exposition and annual meeting to be held at Hotel Statler, Buffalo, N. Y. Ross C. Purdy, 2525 North High street, Columbus, O., is secretary of the American Ceramic society.

Feb. 18-21—

Technical Association of the Pulp and Paper Industry.

Exposition and annual meeting at the Waldorf-Astoria hotel, New York. R. G. Macdonald, 1 East Forty-second street, New York, is secretary of the technical association.

Feb. 18-21—

National Association of Coin Operated Machine Manufacturers.

Fifth annual coin machine exposition and annual meeting to be held at Hotel Sherman, Chicago, C. S. Darling, 120 South LaSalle street, Chicago, is secretary of the association.

March 5-8—

Packaging Exposition and Conference.

The fifth annual exposition and concurrent conferences and clinics on packaging, packing and shipping, sponsored by American Management association, is to be held at the Palmer House, Chicago. Management offices of the exposition are located at 232 Madison avenue, New York city.

March 12-14—

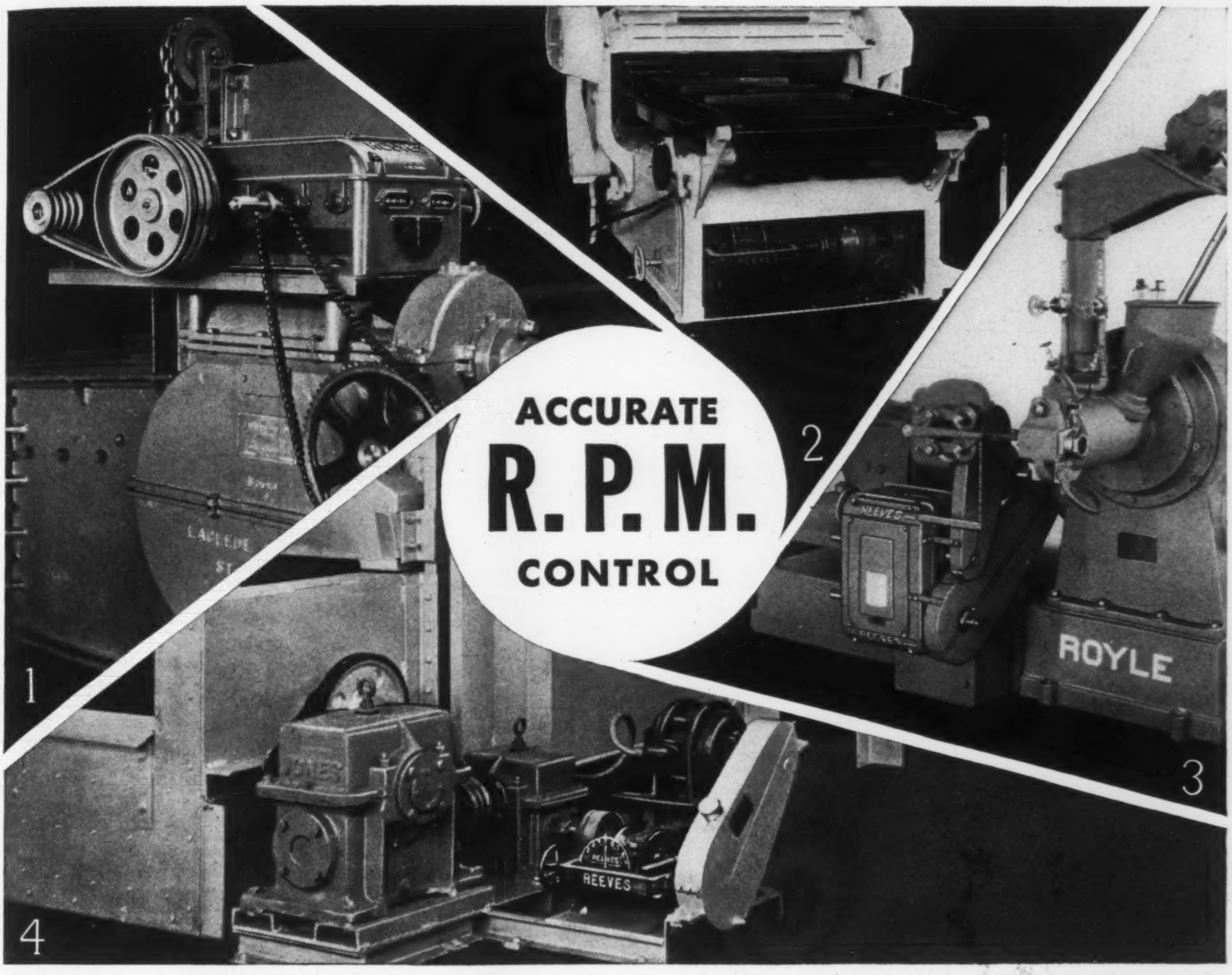
American Railway Engineering association.

Annual meeting and exposition to be held at the Palmer House, Chicago. E. H. Fritch, 59 East Van Buren street, Chicago, is secretary of the association.

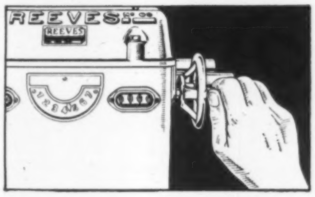
April 22-26—

American Chemical society.

Semi-annual meeting to be held at New York. Dr. Charles L. Parsons, 728 Mills building, Washington, is secretary of the chemical society.



ACCURATE R.P.M. CONTROL



PICTURED above are four machines on which REEVES Variable Speed Transmissions are incorporated as standard equipment. These machines—selected as examples from over 1100 different makes which are standardly REEVES-equipped—illustrate the important operating advantages obtainable on any driven machine with REEVES Variable Speed Control.

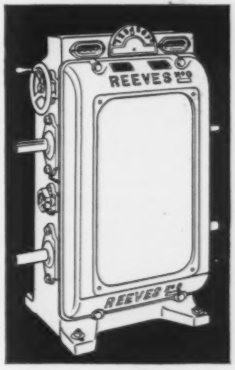
1. STOKER—Any rate of coal feed over a 4:1 ratio is available at the turn of a handwheel on this chain-grate stoker. This permits correct feeding according to grade of coal, BTU and any required steam pressure. Efficient combustion is always secured. Feeding is REEVES-regulated to fractional ounces per hour.

2. MEASURING KNIFE CAKE DEPOSITOR—Handles without damage to dough, the lightest angel food and the heaviest fruit cake, due to REEVES regulation. Note how compactly the REEVES drive and motor are incorporated in base of machine (panel removed to show installation).

3. WELDING ROD COATING MACHINE—Operator can vary feeding speed accurately according to different diameters and kinds of rods, consistency of compounds applied and sizes of dies.

4. HEAT TREATING FURNACE—Accurate control of heating time is provided for handling many different sizes, shapes and kinds of products. This is a traveling type furnace with conveyor regulated through a REEVES with individual motor drive.

To provide these important operating advantages on production machines, a variable speed unit must be infinitely adjustable over a wide range—must be selective to fractions of r.p.m.—must accurately maintain a desired speed *without* fluctuation—must deliver power efficiently—must be durable—must be available in a wide range of sizes, designs, speed ratios and controls. ALL these essential features are combined in REEVES Transmissions, and have been proved in 80,000 applications in 16,000 plants. In all leading industrial centers, there is a REEVES speed control engineer. He is at your service, without obligation. May he call on you?



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Send information on applying variable speed control for standard equipment, as contained in Catalog H-99, which describes the methods used by 1100 different machine builders. (12-34)

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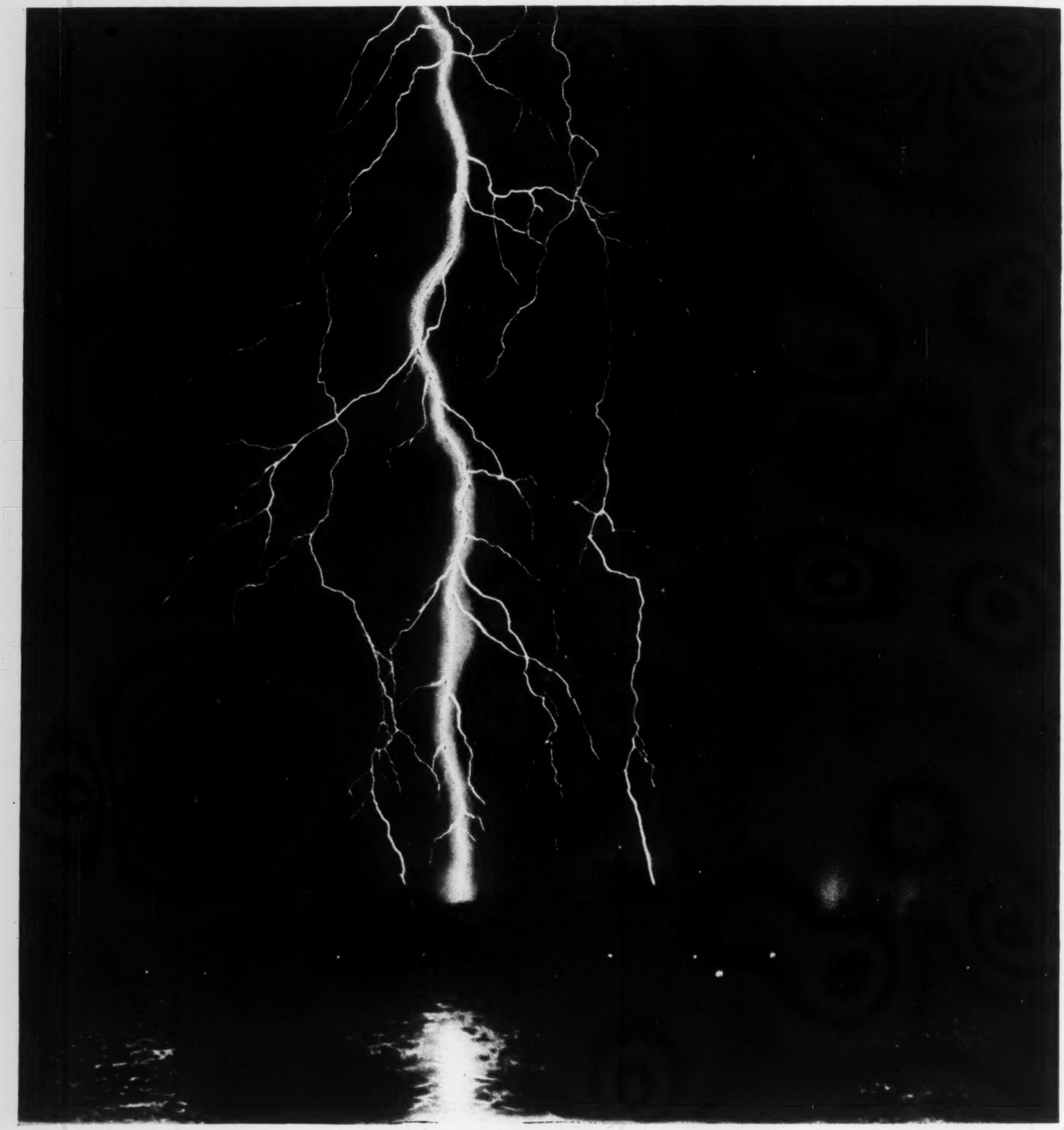

Uncontrolled, electricity is valueless, frequently destructive. Its utility lies entirely in its control. ● In the manufacture of steel, control is equally vital and means of its positive accomplishment have been eagerly sought. Carnegie now offers plain carbon steels in which all quality factors, including grain size, are accurately controlled and predetermined. Their significance to steel users is their greatly extended field of usefulness. Let our metallurgists discuss this important development with you.

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Controlled Steels"

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MACHINE DESIGN
THE JOHNSON PUBLISHING CO., CLEVELAND, OHIO
December, 1934 Vol. 6—No. 12

Reaching the Limits in Bearing Performance

By H. B. Dexter

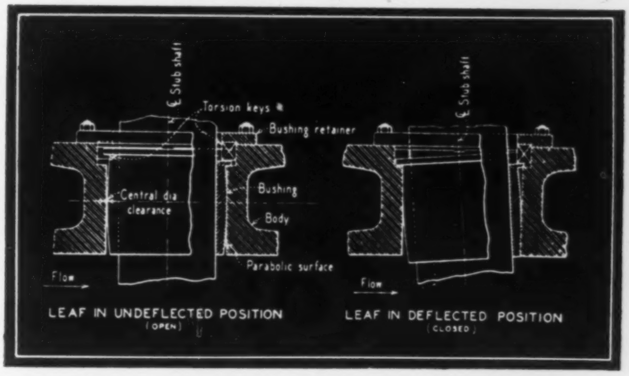
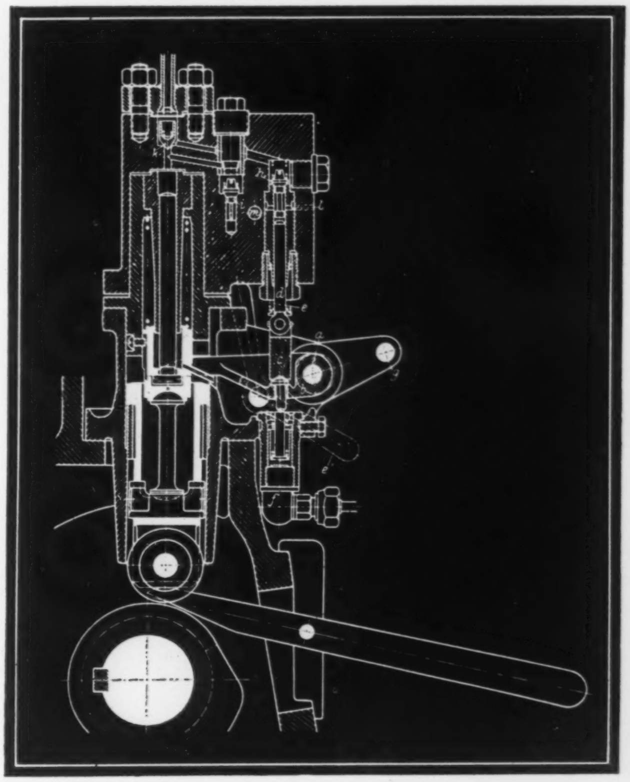


Fig. 1—Special design by which even distribution of reactions is insured

Fig. 2—Cam roller pins endure extreme stresses in diesel design



CLASSICS of friction and bearing research associated with such names as Reynolds, Lasche, Thurston and Moore or our contemporaries, Michell, Kingsbury, Howarth and their younger associates represent all that is orderly in the field of plain bearing design. Side by side in our reference books with the formulas relating unit pressures and perfect film lubrication, originated by these men who have worked within the boundaries staked out by science, are "Useful Tables of Allowable Bearing Pressures", often anonymous. This article is concerned with the latter empirical field and its conclusions are drawn from many years of observation, mostly of the performance of engines and compressors in service, and many tests in which units were forced to their endurance limits of speed and pressure in efforts to reduce weight or price handicaps.

It is not difficult to appreciate that both the rational and empirical schools of bearing design have definite fields of usefulness. In the former not many experimenters have been able to investigate beyond unit pressures of a few hundred pounds per square inch except in the case of the Kingsbury or Michell shoe which represents the ideal of bearing design. Unfortunately, this design reaches the peak of capacity and practicability only in the design of flat-faced thrust bearings. The rational rules for design of journal bearings apply to generator and turbine bearings where the nature of the loading is quite definite and where preservation of original alignment is almost, if not quite, as important as in machine tools. Numerous other schools are not so fortunate.

In machine tools, particularly those of the universal variable speed variety, ideal relations between unit pressure and velocity and definite direction of reaction cannot be assured. "Take up" is of little use, as restoration of the original bearing clearance does not re-establish alignments. The preloaded antifriction bearing which operates without disadvantage over a broad range of loads and speeds regardless of direction is gradually assuming eminence in this field.

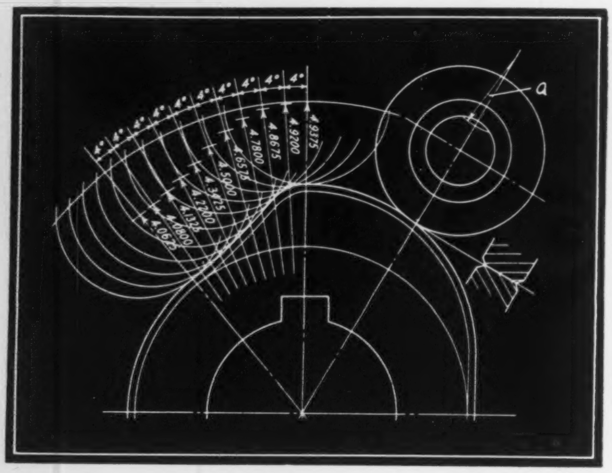


Fig. 3—Groove on unloaded side of pin should be in communication with oilbath

Even should ideal operating conditions exist, when a machine stands idle the measurable oil films seep away under their gravity loading and bearing surfaces remain merely greasy. On starting, an appreciable time expires before oil is brought up and the surface velocities become such as to establish that pumping action which brings about true hydrodynamic lubrication. While it is reported that a unit pressure of 7000 pounds per square inch has been sustained successfully by a Kingsbury bearing, such loads are not usual because the bearing must be designed to permit starting without abrasion. Many, perhaps most, mechanisms never attain the conditions necessary to perfect film lubrication. The unit loading allowable under imperfect conditions depends upon the amount of use, the cost of replacements and the influence of a degree of wear upon the functioning of the mechanism.

An extreme example is the toggle mechanism for operating the gates to the diversion tunnels around the Boulder Dam. According to an interpretation of the published drawings and data, the pins in the wedge-actuating toggles carry unit loads of 30,000 pounds per square inch. These are to be used but once, and crushing strengths of the materials with perhaps reasonable shearing stresses and tolerable deflections governed their design.

The butterfly valves in the penstocks at Boulder Dam have trunnion bearings loaded to 9000 pounds per square inch. The trunnions appear to be of forging steel, and the bushings are of "bridge bearing bronze" which probably is leaded. These valves are for occasional use but on account of the great deflections in the butterfly disks special provision was incorporated, *Fig.* 1, to insure fairly even distribution of the reactions over the trunnion bushings. This measure may be regarded as a necessity in the design of bearings loaded close to the elastic limit of the metals or close to the momentary endurance of the oil film. Edge loading to several times the average value may cause crushing. Bridge articulations have been designed for many decades to load bearings to about the same extent as these butterfly valves, or a little less. Punch, shear and press toggle designs have revealed values of 4000 pounds or more depending on whether the machines are for intermitent use as in plate and structural shops or for continuous use as in automotive production.

Time Interval Is Short

The journal bearings thus far discussed work as low, almost inappreciable, velocities. In diesel engine work the fuel pumps working at hydraulic pressures of 2000 to 10,000 pounds per square inch exhibit some examples of highly loaded pins of hardened steel, working intermittently against bronze or hardened steel at considerable velocities. Here cam roller pins, *Fig.* 2, pressure during forty to sixty degrees out of each two to four revolutions at surface velocities of upward of 200 feet per minute endure unit loads as great as 4000 pounds per square inch. The time duration of this loading, which may be an important factor, is 0.005 to 0.02 second. No doubt the oil film is able to resist complete expulsion during this short interval and is built up during the idle period of several roller revolutions so as to start the high pressure period with the semblance of film lubrication. That the film becomes very thin under pressure is evidenced by the fact that at 4000 pounds

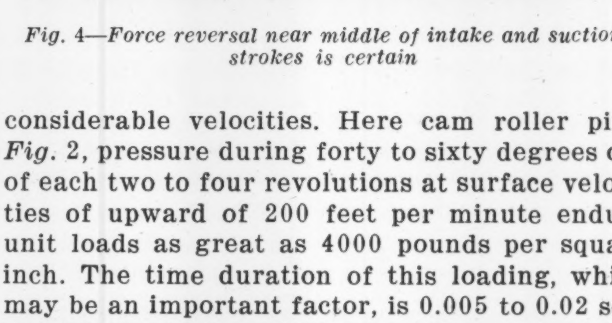


Fig. 4—Force reversal near middle of intake and suction strokes is certain

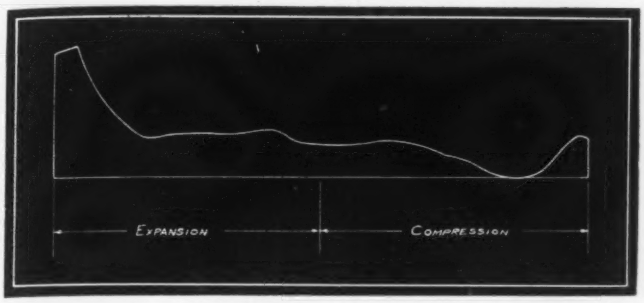


Fig. 5—*In single acting two-cycle engines the forces are always unidirectional*

unit pressure ordinary good quality grinding on pin and roller leaves the surfaces too rough. The characteristic ridges of the ground finish penetrate the film and local overheating causes seizure. To sustain such high unit pressure, even though its duration is short, both the pin and hole must be lapped. The design must be such as to result in very slight journal deflection. Perhaps the slight natural bellmouthing of the hole in ordinary lapping makes the inevitable deflection of the pin tolerable. Cam rollers for such duty should be slightly crowned to insure even loading of their pins and a groove, *Fig.* 3, *a*, on the unloaded side of the pin should be in constant communication with an oilbath or oil under pressure.

Employs Needle Bearings

Commercial antifriction bearings with special heavy outer races have been used as cam rollers but they are too large and heavy for high speed diesel jobs. Space is limited, the roller must be small in order to get the required motion with a cam of reasonable size, and the mass must be as small as possible. However, since the needle bearing has returned in this day of precision production it is doing this job very well. The needles are mounted on pins having a projected area equivalent to 4000 to 5000 pounds per square inch. This simple expression is permissible since the needle diameters do not vary much either side of ⅛ inch. The ratio of cam roller to pin diameter, which must be at least three in the simple design in order that the traction force may overcome the friction moment, may be as little as two with needle bearing support. It is best to run needle bearing cam rollers against the cams without clearance to avoid shock. This is possible only with antifriction bearings.

In designing oscillating bearings or journals making a fraction of a turn each cycle, it is never safe to consider that the wedge film endures even though it may be approximated momentarily if the motion is resumed after relief of pressure. Piston pins and crosshead pins are outstanding examples of endurance in this field. In double acting engines and compressors of all kinds the direction of force may reverse one or more times per stroke. In four-cycle engines force reversal near the middle of the intake and suction strokes is certain, as shown in *Fig.* 4. An exception exists in single acting two-cycle engines in which the forces are unidirectional as in *Fig.* 5.

Forced Lubrication an Asset

Early gas and oil engine designers used the moderate unit pressure of about 1800 pounds on the wrist pins with relief of about 20 to 25 per cent by inertia at full speed, *Fig.* 4. Lubricating oil entered through the piston wall, through a wiper fastened to the open end of the piston, or a bore in the rod drained away a little of the sparse drop feed supplied to the crankpin. Such pins, usually soft, operating in phospher bronze boxes wore rapidly, and since they wore out of round they were difficult to take up. The adoption of forced lubrication with hardened pins on phospher bronze made this articulation quite satisfactory at 1800 pounds per square inch in those designs which afforded cyclical relief of pressure. Lapping of pins and lapping or diamond boring of bushings in place effected a further improvement since there existed on the more perfect surfaces produced by these methods no spots or ridges high enough to cut through the thin oil films. A further improvement was the unsecured or floating pin which tends to remain round. With the lapped job and forced lubrication at moderate pressures of ten to sixty pounds and cyclical pressure relief it is quite feasible to operate with unit pressures of 2400 pounds and light, naturally short-lived engines working their materials close to fatigue limits use starting pressures as high as 3600 pounds with an average of 25 per cent inertia relief at high speeds and full torque.

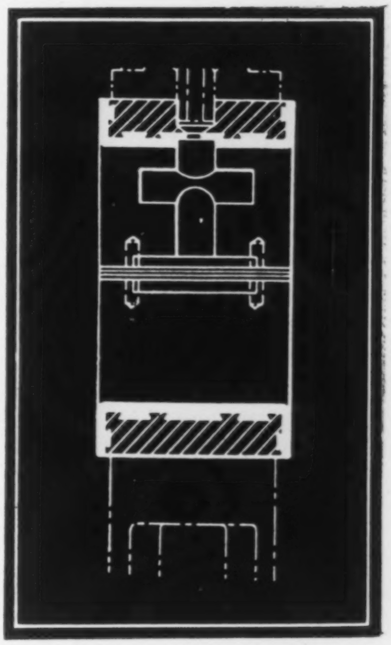


Fig. 6—*Boxes used with babbitt allow some cold working of the metal*

The case of oscillating pins of the same material and workmanship but with unidirectional loading is not so simple. If the mean pressure is low and the least cyclical pressure approaches zero, *Fig.* 5, they may endure a loading of 2400 pounds per square inch quite well. If the least pressure is several hundred pounds per square inch it may be necessary to introduce the lubricating oil by means of special pumps and feed links at a pressure sufficient to float the journal during the interval of least pressure.

Thus for bearings under cyclical loading the following rules seem to apply.

Allow the pins to drift if the motion is oscillating
Use hardened steel pins and bushings or chill cast bronze bushings
Lap all hardened contacting surfaces
If there is no relief from loading, float the pins with high lubricating oil pressure during the period of low pressure

To this may be added that oil grooves should be longitudinal and spaced at angles equal to the angles of oscillation.

It is sometimes difficult to apply high oil pressure to some one particular articulation although it is done in the case of large two-cycle diesel engine crosshead pins. The needle bearing using a loading equivalent to 4000 pounds per square inch or more has done good work on smaller diesel wrist pins for a number of years. The pin is allowed to drift, thus preventing localized wear in the arc of greatest pressure.

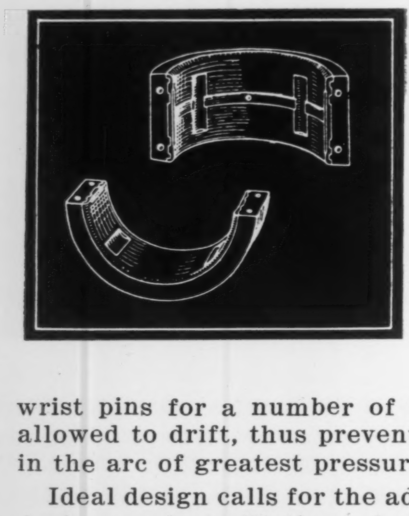


Fig. 7 — Grooving for the effect of quarter boxes may relieve bearing

Ideal design calls for the admission of oil once during each oscillation; however, the roller chain is a remarkable example of more sustained pin loading with oiling by capillarity. Chain pins loaded to 1200 pounds per square inch operate for years without undue wear. Chains should never be stretched so tightly that the pin loading fails to find almost complete relief every few sprocket turns.

With the general use of forced lubrication crankpin bearings loaded to 1000 pounds unit pressure at starting gained many thousands of hours of life between adjustment, and unit pressures up to 1800 pounds per square inch became tolerable. However, this is true only because during a part of the cycle the pressure is reversed or at least relieved to admit oil, and in the most favorable cases the conditions for perfect film lubrication prevail for a short time. Daring designers have forced crankpin bearings at 2400 pounds per square inch relieved 15 to 20 per cent by inertia and centrifugal force. Such bearings live, but the wear per thousand hours is rather great. Unit pressures of 4000 pounds at starting relieved 25 per cent by inertia and centrifugal force have been attempted. The bearings endured an average of perhaps 100 hours but their performance was not trustworthy.

Wear May Be Tolerable

In general, crankpins and journal bearings carrying similar variable loads with cyclical reduction of pressure to less than half the maximum during half the period of the cycle or more may be regarded as permanent under 1000 pounds unit pressure, commercially good at 1500 pounds unit pressure and comparable with the best high speed lightweight machines at 1800 pounds. If considerable wear is tolerable they may be worked to 2400 pounds. All these unit pressures are based on the starting or low speed full torque condition and are relieved 20 to 25 per cent by free forces. The amount of wear that is tolerable depends on whether the loading is unidirectional or not. If the load reverses the bearing will pound out if allowed to attain more play than can be filled by the oil film. If the loading is unidirectional as in two-cycle single acting engines the wear may be continued as long as the pump is able to keep up the oil pressure without harm.

These figures apply equally well to the journal bearings of crankshafts except that lighter loading ($\frac{1}{2}$ to 1/3 that of the crankpin) should be applied because of the need to preserve the original crankshaft bearing alignment.

Where considerable wear is permissible, the cycle of loading may be longer than a fraction of a revolution. In some oil well hoisting apparatus the interval under loading lasts one to four minutes with a similar rest period. Bronze bushed sheave wheels on hardened pins and with forced grease lubrication give creditable service under these conditions under 1500 pounds per square inch and more. Here the rest interval is essential for cooling, any approach to film lubrication being unattainable.

Bearings for certain classes of machines have been designed successfully on the theory that the coefficient of friction is constant for any given construction and thus the friction work and heat may be measured by the product of P the mean unit pressure and V the velocity in feet per minute. Certain empirical values are assigned to the product PV as for instance

Class X $PV = 50{,}000$ for electrical machinery
or
Class Y $PV = 500{,}000$ for locomotive journal boxes

Naturally the PV theory may be applied to a cyclically varying load only when the coefficient of friction is fairly constant. This eliminates any condition in which the breaking down of the oil film must be tolerated. In simple fact it cannot be applied successfully to compare Class X bearing to Class Y bearings. The latter wear rapidly which of itself indicates a close approach to metallic contact. The maximum unit pressure considered along with the possibility of reestablishing the oil film before the next cycle rules these cases. When the Liberty motor was succeeded by newer line or Vee models having much stiffer shafts it was observed that unprecedented *PV* values had been used successfully in certain bearings. A skeptical mind reviewing the case noted that the unit pressures had remained the same. The bearings had been increased in diameter and shortened to attain greater torsional stiffness but their projected area had not changed. This development is taking place in many kinds of machines today. When the designed speed of a machine is doubled it is not feasible to halve journal diameters and double their length to preserve *PV* relations. Often quite the reverse takes place. Friction heat is increased, naturally, but increased oil pressure resulting in increased flow of oil through the cooler is made to overcome this small difficulty.

It has even been pointed out that the amount of friction heat that may be dissipated into the oil cooler by forced lubrication is increased by the greater side leakage of short bearings.

Hardened Steel Is Best

As to bearing and journal materials not much need be said. Bearing design is fundamentally a lubrication problem. Hardened steel surfaces are always best because they take the best finish and retain it longest. Hardened surfaces working together under good conditions of lubrication and alignment are a superior combination but they are not kind to each other if accidental contact occurs under load. Hardened steel journals and hard cast phosphor bronze will stand much more abuse under boundary or merely greasy lubrication. Rolled soft brass or bronze should never be used for bushings in severe service.

Leaded bronze or copper will stand a lot of pounding and some more heat than babbitt. It will bring a machine home when babbitt would have failed, but usually at the expense of considerable wear on the journals. Babbitt stands up to hammering far better in the old fashioned boxes possessing some anchorage to allow cold working of the metal without failure due to extrusion as in *Fig.* 6.

May Apply Counterweighting

The greatest care should be exercised in the placing of oil feeds at points of low pressure. Chamfers at the box joints often are used to distribute oil, but if the load is a centrifugal one the journals may ride them during part of each revolution with very bad results. This difficulty may be overcome by grooving for the effect of quarter boxes, *Fig.* 7, the bearing being relieved little or not at all at the joint, or counterweighting may be applied to relieve the bearing of radial loading.

The accompanying table indicates the maximum safe endurance of bearings of certain classes. For pins with maximum loading of 4000 to 8000 pounds unit pressure, abrasion resisting steels such as high carbon high chromium steels or one of the high manganese steels are best. An alloy suggested is carbon 2.20-2.40, chromium 14.00-15.00. For shock loads it is often necessary to use case hardened steel. The base material employed depends considerably on the stress. It may be anything from SAE 1010 to 1020 or if stresses are high it may be better to use one of the nickel or nickel chromium case hardening steels.

The abrasion resisting steels will not become quite so hard as the case hardening steels. The latter may be worked with Rockwell hardness varying from 50 to 60 C scale; the lesser hardness will be the result of drawing for toughness under shock load. It is questionable whether any steel of the carbon forging variety under .45 carbon should be used for journals. Very much higher carbon often is prohibited by the necessity for toughness of the member.

Maximum Safe Endurance of Bearings

Loading Cycle					Lubrication		Journal		Bearing	
Max. Unit Pressure	**Min. Unit Pressure**	**Reversals per Cycle**	**Rotation**	**Surface Velocity Ft. per Min.**	**Lubricant**	**Pressure**	**Mat'l.**	**Finish**	**Mat'l.**	**Finish**
8000				Negligible	Grease		Hard. Stl.* Cast Iron Lead Br.	Grind	Hard. Stl. Cast Iron Lead Br.	Grind
4000	0		Unidirect.	100 ft.	Petroleum Oil	Bath to 75 lbs.	Hard. Stl.	Lap	Hard. Stl.	Lap
3600	0	2–4	Oscillat.		Petroleum Oil	Bath to 75 lbs.	Hard. Stl.	Lap	Hard. Stl. Chill Br.	Lap Diamond Bore
2400	0	2–4	Oscillat.		Petroleum Oil	Bath to 75 lbs.	Hard. Stl.	Lap	Phos. Br.	Diamond Bore
1800	0	2–4	Oscillat.		Petroleum Oil	Bath to 75 lbs.	Hard. Stl.	Lap	Phos. Br.	Diamond Bore
1800	0	None	Unidirect.	1000 2000	Petroleum Oil	25 to 75 lbs.	Mach. Stl.	Turn & Polish	Leaded Br. Babbitt	Diamond Bore
1500	X	None	Oscillat.		Petroleum Oil	Above X	Hard. Stl.	Lap	Leaded Br. Babbitt	Diamond Bore
1500	0	2–4	Oscillat.		Petroleum Oil	25 to 75 lbs.	Hard. Stl.	Lap	Phos. Br.	Diamond Bore
1500	0	None	Unidirect.	1000 2000	Petroleum Oil	25 to 75 lbs.	Mach. Stl.	Turn & Polish	Leaded Br. Babbitt	Diamond Bore

*See article for description of materials.

SCANNING THE FIELD FOR IDEAS

MOVIE CAMERA OBVIATES GUESSWORK

As MACHINERY speeds continue to increase, an inevitable trend in our modern production scheme, designers' problems multiply proportionately. Much more is being demanded of machine parts in all fields and it is the engineers' responsibility to assure their successful performance. Guesswork in present day design is suicide—the designer must know precisely what can be expected of each mechanism and element thereof.

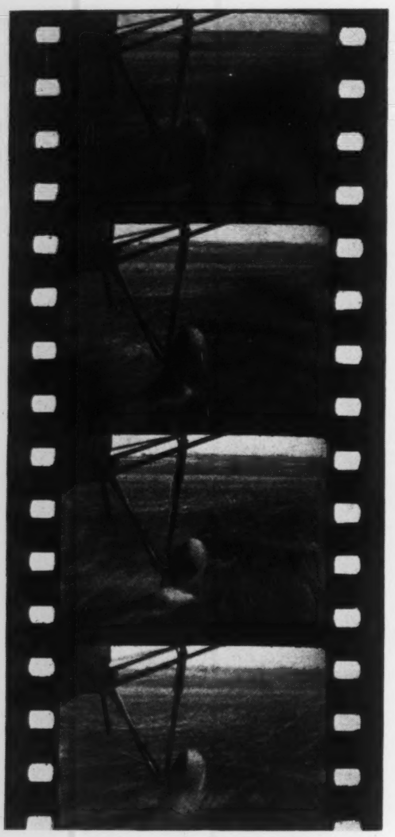


Fig. 1—A motion picture camera caught the action on an airplane tire under rigorous service while rounding a curve, thus enabling engineers to study distortion. This is a striking example of the application of the movie camera in affording a new tool for observing design performance of machines in all fields, with a view toward redesigning to correct any mal-operation that might occur

Furthermore, the engineering staff must employ some device to enable it to observe the action of machine components in operation. Because a unit will perform satisfactorily at low or intermediate speed does not necessarily mean that at top speed the same results will be obtained. That is where the high speed camera comes to the engineers' assistance. Its use makes possible the observation of a machine which although running at high speed appears on the screen to be barely moving. The film discloses and records what is taking place and any existing faulty conditions can be studied easily.

As an instance, it is interesting to see how motion pictures played an important part in the development of the well-known Goodyear airwheel. Many tests were carried out to ascertain the action of tires under all conditions. Motion picture cameras were fastened on planes in proper position to photograph the airwheel in action. An example of the visual record obtained is shown in *Fig.* 1. Note the tire "laying over" while taxiing around a curve. Pictures such as these give engineers an excellent insight into such factors as strain on the various elements involved in the operation.

IDEAS FLOURISH IN REFRIGERATION

REFRIGERATION offers a field that seems almost inexhaustable insofar as ideas are concerned. While its progress mechanically in domestic application continues, recent design activity appears to be centered on its adaptation to transport equipment. Two decidedly interesting developments have come to attention that may offer further suggestions.

One is the Louis Allis dynamatic drive (M.D. Oct., p. 58) which is a combined speed controlling power transmission and alternating-current motor for converting variable speeds of an auto engine to correct number of revolutions for operating a refrigerating compressor on a moving truck, *Fig.* 2. By connecting the motor to a regular A.C. power line the unit will continue

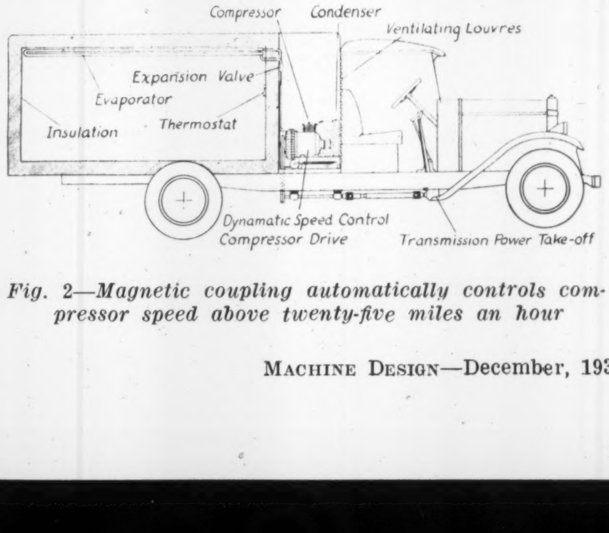


Fig. 2—Magnetic coupling automatically controls compressor speed above twenty-five miles an hour

to maintain the refrigeration unit in operation while the vehicle is in the garage.

Another innovation is a combined refrigeration and fuel system which utilizes a hydrocarbon distillate called propane gas that was considered useless by the oil refining industry for years. The gas is carried in twin cylinders under the truck and led through a pipe upward to a heat exchanger at the front top of the truck where the atmospheric temperature of the liquid is removed. It then passes through an expansion valve from which it is conducted into evaporator or cooling unit pipes at the top of the truck body at a pressure of about five pounds. The gas subsequently passes to a mixing valve and later is fed into the intake manifold of the motor as fuel.

AUTO HURDLES ANOTHER TRADITION

HOW long it will be before rear-engined autos become common is a matter of speculation, but one thing is certain—the automotive atmosphere is charged with much favorable comment. This type of design, already accepted to an appreciable extent in Europe (like independent springing) soon may be offered by American engineers for public approval. Another indication that the Continent is tending toward rear engine installation is seen in a copyrighted article recently published in *Automotive Industries*.

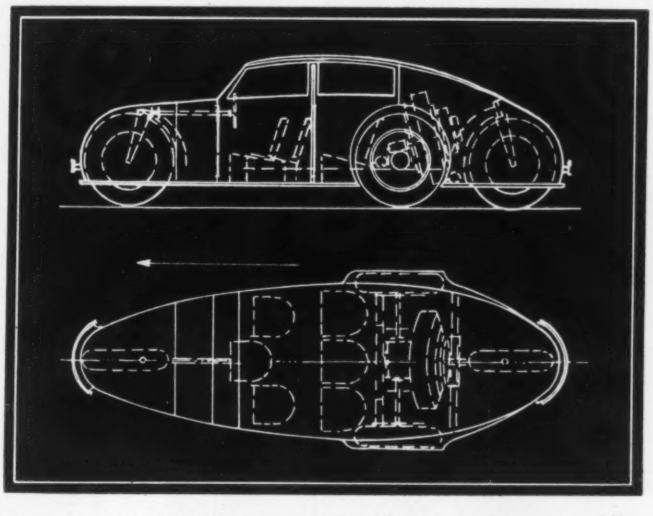


Fig. 3—Is this French design a harbinger of the automobile that is to be adopted generally?

According to the report, Gabriel Voisin, one of the most advanced of French designers, has announced that he is preparing a car, *Fig.* 3, which embodies a radial engine mounted at the rear and drives independently sprung wheels through a four-speed transmission. To obtain the best airflow effect the usual pair of steering wheels in front are replaced by a single wheel in front and another in the rear. Although this increases the total length of the car, it gives an extremely short turning radius and permits enclosing the wheels in the streamlined body. The drive is on the two center wheels.

William B. Stout is carrying experiments on a rear-engined car to rapid conclusion. Results should be watched.

SEPARATING MATERIALS BY WEIGHT

SEPARATION of materials is a process problem that designers of machinery frequently must solve. Those on whom this responsibility falls might profitably examine a simple but interesting method, *Fig.* 4, for separating anthracite coal from slate, sand and other impurities. The equipment is known as the Chance cone.

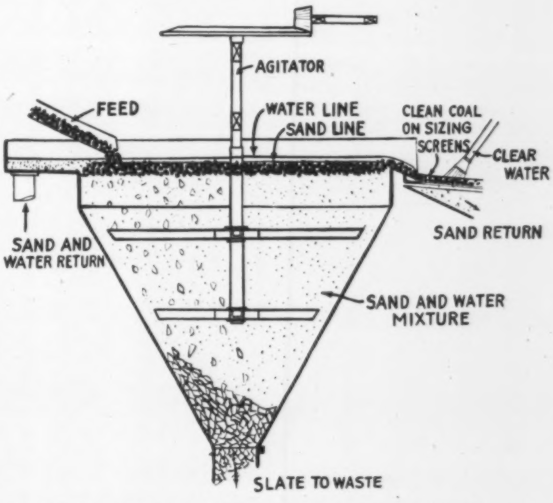


Fig. 4—Coal being lighter than sand and water mixture, floats and is separated from impurities

Pure coal is lighter than the agitated mixture of sand and water in the cone while slate and bone are heavier. Because of this the coal floats and is washed over the lip of the cone thus being separated from the impurities which sink and are carried out through the bottom of the unit.

ALUMINUM ADAPTABLE TO HARD FINISH

ELECTRO-COATING of pistons by a process developed recently by Chrysler engineers is considered a notable advancement. In the past aluminum pistons although considered by leading engineers superior to other types, had the drawback of being soft enough to be subject to considerable wear and scuffing. This new process now makes possible a surface coating on aluminum pistons that is extremely hard.

The process is simple. Pistons are immersed for seventeen minutes in a tank containing a solution of sulphuric acid maintained at a temperature of seventy degrees. While in the solution the piston, carried on a conveyor, is the anode for the coating operation. It emerges from the tank with an aluminum oxide surface approximately 0.00025 inch thick.

Securing Corrosion Resistance at

By Allen F. Clark

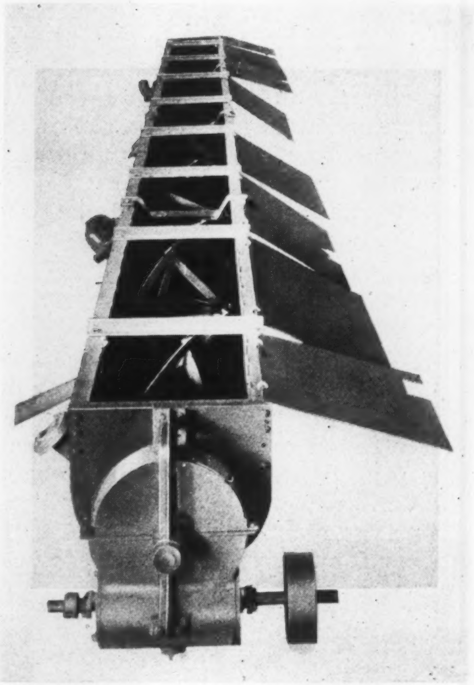


Fig. 2—Clad material prolongs life of crystallizer unit

ONE OF the many delicate decisions that the designer must make is a determination of the extent to which he can improve the quality of materials in his machine without increasing costs to the point beyond which users will not pay for the increased benefits. Better materials always give considerably better machines; but in this day when all too many purchasers consider price as paramount, sales often go to the lower priced machine. This condition is not always true because better materials often are the key to success and many buyers take the long-range view in purchasing by considering maintenance costs. However, the situation occurs frequently enough to necessitate great care in design.

The possibility of obtaining both low cost and the excellent service characteristics of superior materials is usually neglected by the engineer who considers such a Utopian condition as unfeasible. Nevertheless, there are available sheets of pure nickel and of stainless steel that offer to the designer the advantages of these metals at a moderate cost. These are clad sheets or plates formed by the intimate combination of a thin layer of an alloy with a mild steel base sheet into a single, composite sheet such as stainless-clad steel and nickel-clad steel. Such plates are adaptable to all types of construction in which plates wholly of the veneer or cladding would be advantageous. In other words, these clad materials can be applied where entire nickel or stainless steel are advantageous at reduced cost and have exactly similar corrosion resistancy properties as the material used for the veneer.

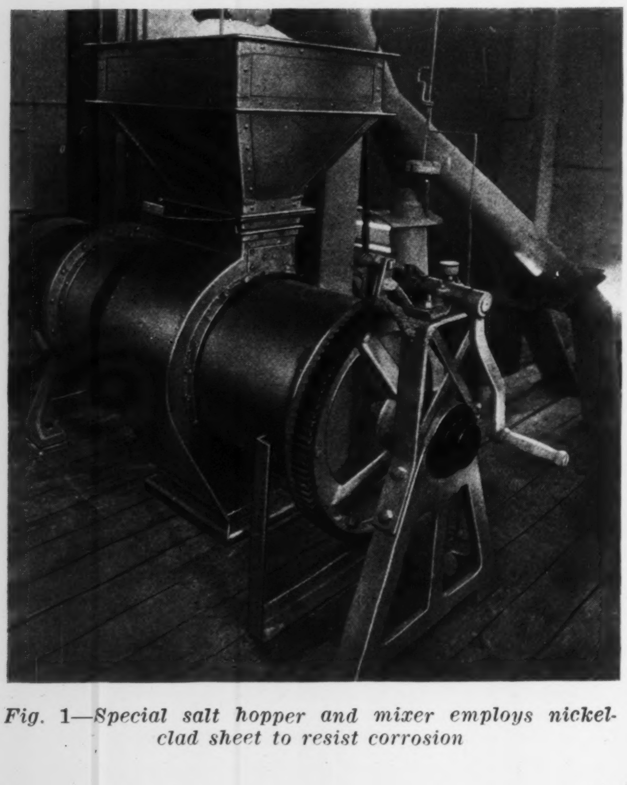


Fig. 1—Special salt hopper and mixer employs nickel-clad sheet to resist corrosion

Continuous Surface Necessary

The use of these materials invariably imposes the requirement of a continuous alloy surface to prevent attack on the steel base plate, or contamination of the product by the mild steel. Consequently such applications as perforated sheets or plates in which the underlying mild steel side of the clad material might be subject to corrosive attack are eliminated. Likewise the clad sheets are excluded from those uses where corrosive attacks occur on both sides of the metal. Again, it should not be used for heat applications in which the mild steel side would be adversely affected due to oxidizing and other factors which may militate against the mild steel at elevated temperatures. With these few exceptions, clad sheet can be applied wherever the properties of the facing material are useful.

at Low Cost with Clad Sheets

In designing any vessel where the vessel, its fittings or parts, are to be in contact with liquids, it is the best practice to have all fittings and parts of the same material as the veneer itself. Design data follows closely the practice used in designing in mild steel. In certain cases, however, certain noncorrosive fittings can be used with clad steel.

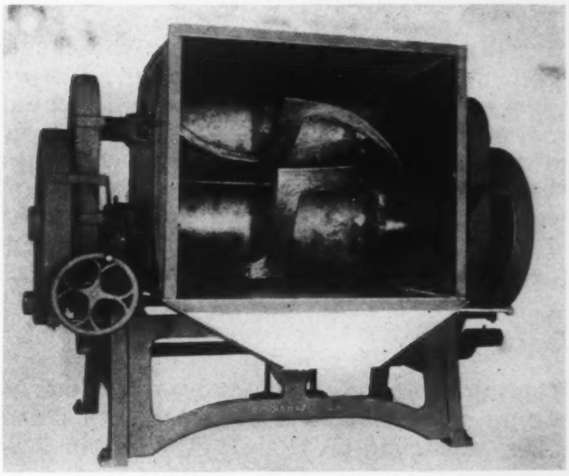


Fig. 4—Corrosion is combated in mixers used for cellulose products

Strength Is Improved

The physical properties of the clad sheet are a combination of the physical properties of the two metals which form the combined sheet or plate. Strength of the alloy or the mild steel is not affected by being in combination with the other material. The user is assured that the tensile strength of the clad material is as high or higher, than the strength of the two materials taken individually.

Nickel-clad plates may have a nickel layer which is five per cent or more of the total thickness of the plate, depending upon the degree of corrosion or abrasion to be met in service. Two finishes are available: "regular hot rolled" and "hot rolled and cleaned." In the former, the nickel surface has a glossy, nickel-oxide film, dark olive brown in color, which distinguishes nickel from steel surface. In "hot rolled and cleaned" finish, the oxide film is removed from the nickel surface, giving it a matt appearance nearly white in color. Steel of the composite plate in nickel-clad sheets is low carbon steel and is regularly furnished, unless otherwise specified, of flange quality with a nominal tensile strength of 55,000 pounds per square inch. The nickel contributes an additional strength to the steel plate and, in general, increases the ultimate tensile strength 500 to 5000 pounds per square inch. Table I shows the results of tensile tests made on the nickel-clad material. In this material the thermal coefficients of expansion of nickel and mild steel are nearly identical and therefore it is possible to roll plates equally as large as mild steel plates.

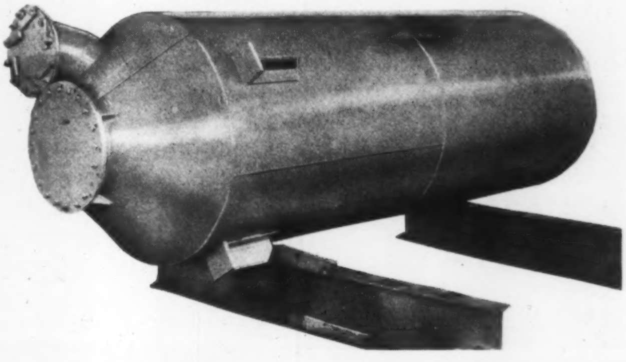


Fig. 3—Forced circulation evaporator is fabricated from 18-8 stainless-clad steel

Stainless-clad sheets may be produced with a variety of stainless steel surfaces, and a stainless cladding varying from a very thin layer to a thickness comprising 30 per cent or more of the total sheet or plate thickness. It has been found, however, that the 18-8 stainless steel cladding, comprising 20 per cent of the total sheet or plate thickness, satisfies most commercial requirements. For this reason, the manufacturers have standardized on this cladding except in special cases where tonnage requirements justify a variation from this specification. Tensile strength of stainless-clad sheet is approximately 65,000 pounds per square inch, depending on the carbon content in the base metal which is varied to meet users' requirements.

Of special importance to the designer is the fact that there is no separation of the alloy and steel under normal conditions of temperature change, pressure, vacuum or mechanical shock. Composite steel can be sheared, bent, flanged, formed, welded or riveted without cracking or peeling. Drilling and tapping operations also can be performed.

Cold operations, such as bending, flanging, forming, shearing, preparation of rivet holes, and the like, are done as with common steel without the necessity of providing special tools and equipment, or changing the manner of performing the work. Hot operations, such as flanging or flaring, follow the same procedure as with steel so far as the actual temperatures, tools and manner of working is concerned. The essential difference over steel in working duplex plate is the necessity of providing a means of heating to prevent possible injury to the veneer. Shearing, punching, drilling and tapping operations should be performed so that the veneer is cut first.

Riveting as a method of joining the sheets is not considered as efficient or economical as welding, but must be used in some cases on account of special designs or code regulations. Rivets must be of the same analysis as the metal cladding. In the case of riveted tanks, it is necessary to weld as well as to rivet in order to cover the exposed mild steel on the plate edges. Calk welding will generally cost as much as butt welding.

Alloy Electrodes Used

Welding of the clad sheets may be done with either an alloy electrode used for both sides or an alloy electrode on the alloy side and a mild steel electrode on the mild steel side, the more economical procedure. The deposited weld metal on the clad side gives a service which resists the action of corrosive substances equally as well as the cladding and satisfies the requirement that the surface exposed to corrosion be a continuous alloy surface. Beveling for welding should be specified on the mild steel side. Also, fittings may be attached by welding employing the same procedure.

Applications of the clad sheets have been confined mainly to those heavier machines which incorporate containers or other structures requiring special corrosion resisting properties. For example, the material has been used for casein cookers, hoppers used in dyestuff manufacture, textile dyeing tanks, soap crutchers and many other similar machines. *Fig.* 4 shows a steam-jacketed mixer which has a body of nickel-clad steel. Many larger mixers for use in the manufacture of a cellulose product have been built of this clad material.

Fig. 5—*Alloy surface affords sanitation in the packaging of food products*

A 40-foot crystallizer unit employing nickel-clad steel, used in cooling iron-free 50 per cent caustic soda is shown in *Fig.* 2. *Fig.* 1 shows a special salt hopper and mixer which employs this material.

TABLE I

Results of Tensile Tests on Nickel-Clad Steel

	Yield Point	Ultimate Tensile Strength, pounds per square in.	Per cent Elong. in 8 inches	Per cent reduction of area
5/16-inch plate clad 0.50-inch nickel				
Carbon Steel	42,200	51,200	41.75	72.9
Nickel-Clad Steel..	45,600	57,500	29.0	52.8
½-inch plate clad 0.050-inch nickel				
Carbon Steel	36,800	60,300	27.5	50.7
Nickel-Clad Steel..	40,500	60,900	30.0	58.0
⅝-inch plate clad 0.062-inch nickel				
Carbon Steel	32,900	61,000	26.3	58.8
Nickel-Clad Steel..	40,300	61,800	30.0	62.5

Sheet Affords Sanitation

For corrosion resistance and economy, the forced circulation evaporator shown in *Fig.* 3 is fabricated from stainless-clad steel. Heating elements and fittings are all of the material. Santitation dictates the employment of clad sheet for the table conveyor used in bottling cherries, *Fig.* 5. The material has a permanent high polish and is easy to keep clean.

For their courteous co-operation in the preparation of this article and for the illustrations used, MACHINE DESIGN wishes to acknowledge the assistance of Illinois Steel Co., Ingersoll Steel & Disc Co., International Nickel Co. Inc., and Lukens Steel Co.

They Say—

"No program could be more suicidal than the abandonment of our new mechanisms."—Donald Richberg, National Emergency council.

□ □ □

"The third and final stage in the evolution of business is where the concern comes to realize that its welfare and the welfare of its employes and customers is an integral part of the welfare of the nation as a whole, and that its selfish interests can best be served by the advancement of the welfare alike of all with whom it comes in contact—its employes, its suppliers, its customers, and even its competitors."—J. Struthers Dunn, president, Struthers Dunn Inc.

Overcoming Fatigue of Shafts at Press-Fitted Units

By R. E. Peterson
and A. M. Wahl

ALTHOUGH nearly all shafting carries such machine elements as gears, pulleys, wheels, couplings, rotors, etc., little data have been available on which to estimate the effect of these members on the endurance strength of the shaft, with the result that sometimes rather surprising failures occur.

Considerable work done in German laboratories has shown that the ordinary endurance limit of fatigue specimens can be increased 5-30 per cent (depending on material) by rolling under sufficient pressure to deform the surface plastically. This expedient was also found to be particularly effective in raising the endurance strength of press fits.

Material Changed Fundamentally

With regard to the reason for the increase of fatigue strength due to rolling considerable difference of opinion exists. Professor O. Foppl, of Braunschweig (Wohler Institut) attributes the increase of fatigue strength to a fundamental change in the material in the outer layer of the specimen, resulting in a denser material having a closer and differently orientated molecular structure, a changed microstructure and a somewhat higher specific weight. Professor A. Thum of Darmstadt believes that the increase is due to favorable residual compressive stresses at the surface as a result of rolling. It is not inconceivable that both effects are present.

The results of Westinghouse fatigue tests made on the specimens shown in *Fig.* 1 are indicated in *Fig.* 5 and summarized in Table I. It will be noticed that all results are compared with the ordinary endurance limit of 0.3-inch diameter beam specimens of the shaft material—31,700 pounds per square inch. Previous size effect tests, without stress concentration effect, of steel purchased under the same specification showed that the effect, if any, was not large.

In Table I fatigue stress concentration factors (K) as ordinarily defined and as used in design formulas are given. In the press-fit tests where not only stress concentration is involved, but also a rubbing corrosion effect, the term "fatigue stress concentration factor" is not an accurate one, but since we could not find a better term it was decided that for this paper we would adhere to "fatigue stress concentration factor," defined as follows in the press-fit case.

$K =$ [*Ordinary endurance limit of specimen with large contour radius*] ÷
[*Endurance limit of press-fit specimen* ($S = M \div \pi d$ 3/32]

Comparing series 2 and 3, it is apparent that radial pressure is an important variable. The heavy press fit involves stress concentration, a three-dimensional stress system at the point of failure, and rubbing corrosion. The very light press fit involves mainly rubbing corrosion (with possibly some stress increase at the corners due

FATIGUE of shafts with press-fitted members is a problem which frequently arises in connection with rotating machinery involving gears, wheels, couplings, rotors, etc. Mr. Peterson and Mr. Wahl, both members of Westinghouse Research Laboratories, have been outstanding in the study of fatigue problems. The latest results of their investigation are included in a paper presented before the American Society of Mechanical Engineers from which this article is abstracted.

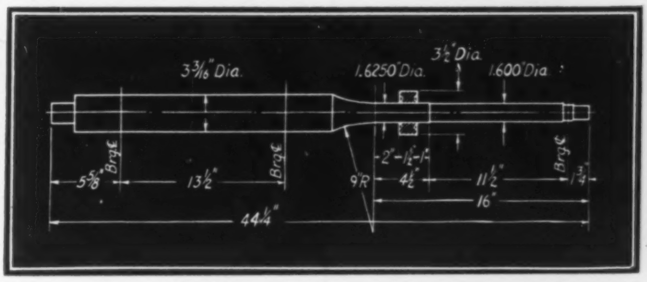


Fig. 1—Typical specimen used to determine effect of press-fitted units on fatigue of shafts

to bending). It would therefore appear that the decrease in endurance strength of an ordinary heavy press fit is due to a localized stress system acting on a material weakened by rubbing corrosion.

In *Fig.* 3 a plot of all available radial pressure data as affecting endurance strength is shown. In the case of the Darmstadt tests, it appears that over a wide range the endurance strength is independent of pressure. This is probably because a condition of yielding has been reached at the surface of the collar, in which case the maximum stress peak no longer increases with increase of allowance. In *Fig.* 3 dotted lines have been drawn towards zero pressure to connect up with the ordinary endurance limits. With the limited data available the form of these curves is not definitely known.

Returning to Table I, one might expect that series 1 would show an even lower endurance limit than series 2, because of size effect. The difference may be due to two reasons. The pressure in the case of series 1, although not determined, was probably less than 5000 pounds per square inch because the collar is a relatively thin one for the customary 0.001 inch per inch of diameter maximum allowance. The length of fit in series 1 is much shorter in proportion to the shaft diameter than in series 2, thus decreasing the stress concentration due to bending considerably.

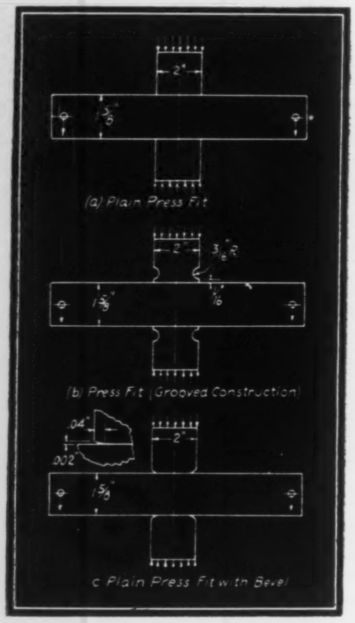

2"
1 5/8"
(a) Plain Press Fit
2"
3/16" R
1/16"
1 5/8"
(b) Press Fit (Grooved Construction)
.04"
.002"
2"
1 5/8"
c Plain Press Fit with Bevel

Fig. 2—Comparison tests have been made of plain press fits, top, press fits with edge beveled off, bottom, and press fits with grooved construction, at center

Solid specimens of the same contour as the press fit specimens were included in order to throw some light on the relative stress concentration effects. The endurance strength of the solid comparison specimens (series 4—Table I) was found to be 14,000 pounds per square inch, somewhat lower than the corresponding value of the heavy press fit—15,800 pounds per square inch. Due to a mistake a series of "solid" specimens was made with a small outside diameter (1-15/16 inch—series 5) but the results are interesting so the data are included. The endurance strength was found to be 16,500 pounds per square inch as compared to 14,000 for the larger outside diameter specimens. The difference is apparently due only to difference in stress concentration, and should be shown readily photoelastically.

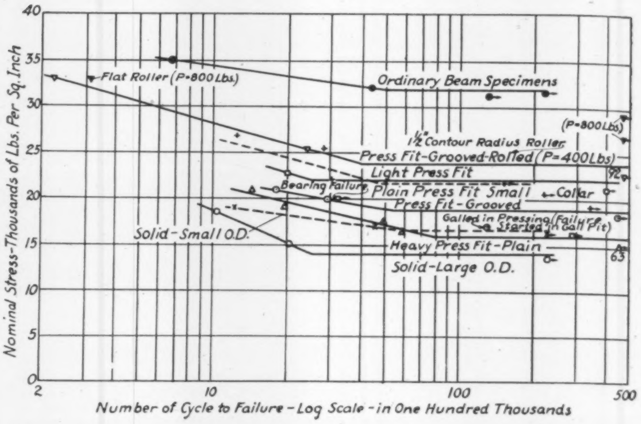


Fig. 3—Available radial pressure data as affecting endurance strength

Rupture Area Well Defined

Typical appearance of the fractured surfaces of a plain press fit specimen (series 2) and a "solid" specimen (series 4) is shown in *Fig.* 4. The "solid" specimens had totally enclosed well-defined rupture areas displaced from the axis, as is customary in specimens of this kind. The press fit specimens, however, showed irregular rupture areas, some of which were totally enclosed, some segmental in form, but as a whole not following any clear-cut order. This is to be expected since due to small surface irregularities the pressure actually is not perfectly uniform and consequently the edge stresses must vary somewhat around the periphery. "Beach marks" were quite pronounced on the fracture surfaces of the press fit specimens, showing that cracks originate at a number of places on the periphery.

Failure generally started on the shaft surface inside the press fit, varying from 0.02 to 0.25 inch from the edge of the collar, except in the case of two highly stressed rolled specimens (breaking at 224,000 and 313,000 cycles), where failure started right at the edge. The explana-

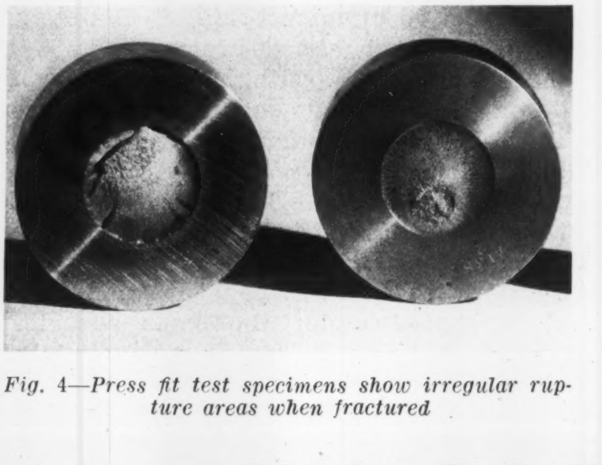
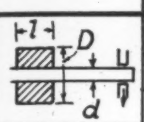
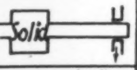
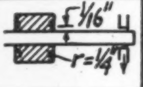


Fig. 4—Press fit test specimens show irregular rupture areas when fractured

Table I Endurance Strength of Fitted Specimens

No.	Type of Fit	Material		Fit	Remarks	Endurance Strength		
		Specimen[a]	Collar	Pressure Lbs/Sq. In		Lbs Per Sq. In.	% Ordinary Endurance Limit (See Notes)	Stress Concentration Factor[b] K
1		Medium C Steel[c]	Medium C Steel[c]	Not known[e]	d=2½" D=3 5/16" l=1½"	21600	68	1.5
2				≈16000	d=1⅝" D=3½" l=1½"	15800	50	2.0
3		"	"	≈ 90	" " "	22000	69	1.4
4		"			" " "	14000	44	2.3
5		"			" D=1 15/16" "	16500	52	1.9
6		"	"	≈12000	" D=3½" "	18700	59	1.7
7		"	"	≈6000	" " " Surface Rolled Roll Force-400lbs.	23800	75	1.3

Notes

a-1⅝" Dia. (See Fig. 1)

b-Stress concentration factor
K = Ordinary endurance limit of
Endurance limit with stress
specimen with large contour rad.
concentration present.

c-0.42%C, 0.62%Mn, 0.15%Si, 0.028%S, 0.017%P, yield str.-37200 Lbs/Sq. In., ult. str.-73800 Lbs/Sq. In., elong.-34%, red.-51%

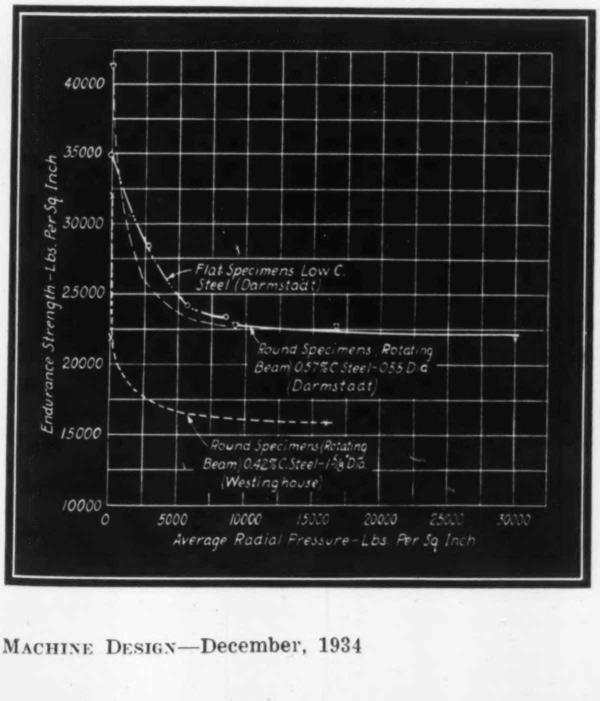
e-Probably less than 5000 Lbs./Sq. In. (See comments in paper)

tion may be as follows. In press fit tests, rubbing corrosion causes considerable reddish-brown oxide powder to accumulate at the edge of the collar fit after the test has been run for some time. This may be considered equivalent to the wearing away of some of the material for a distance in from the edge, with a consequent shift of peak stress. In the case of the highly stressed specimens, the total life was only 3-4½ hours so that the opportunity for corrosion and wear was not the same as in the other specimens which lasted over 1,000,000 cycles.

To determine the principal stress differences photoelastic tests were made in conjunction with the well known fringe method (monochromatic light being used). The photoelastic specimens were made of C-25 bakelite plates approximately 0.34-inch thick. The following different cases were tested:

Case 1. *Plain Press Fit.* In this case (*Fig.* 2*a*) a nominal press fit pressure of 1480 pounds per square inch and a nominal bending stress of 2020 pounds per square inch were used. The stress conditions in this test correspond approximately to the fatigue tests wherein the nominal bending stress at the endurance limit was about 1/3 greater than the nominal compressive stress due to the

(*Continued on Page* 67)



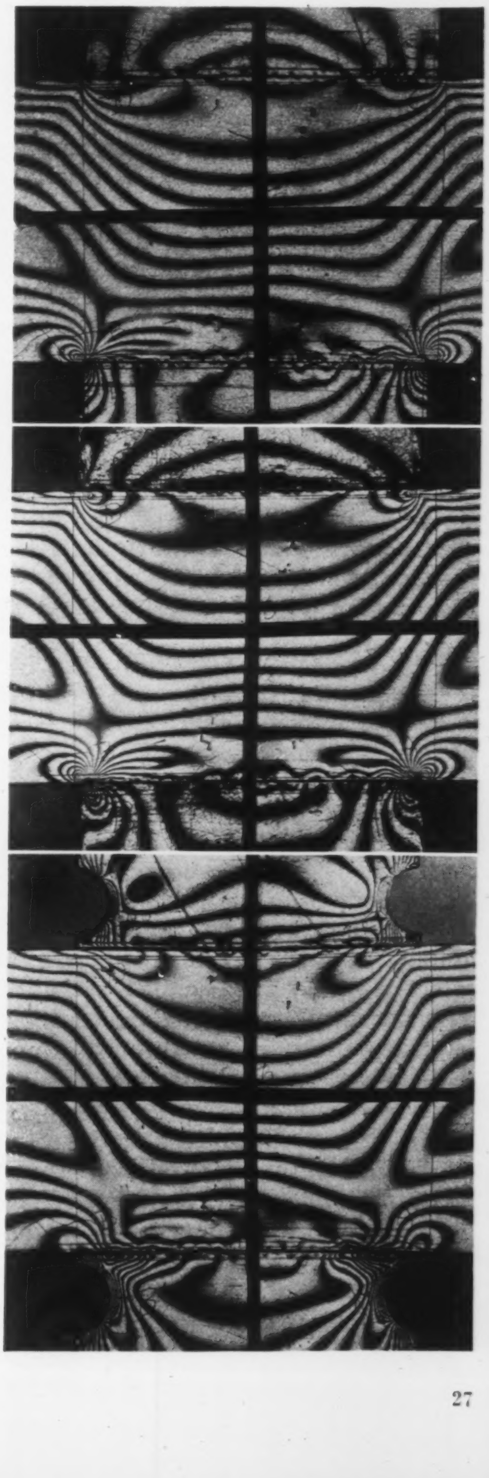


Fig. 5—(*Left*) — *Results of fatigue tests indicate best design procedure. Fig.* 6 — (*Right*) — *Fringe photographs indicate stress concentrations with different types of press fits*

Auxiliary Devices Control Success of Hydraulics

By John S. Carpenter

Consulting Engineer, Detroit

SUCCESSFUL application of hydraulics to any machine will depend largely upon the correct selection of hydraulic devices for the individual purposes intended. Only by and through mechanical devices can hydraulics be applied to any purpose. Much valuable material has been published on this subject, some of which is listed on page 23 of the January, 1934, MACHINE DESIGN, but it is advisable to review some of the fundamental hydraulic principles before engaging in a complicated design.

Various hydraulic devices can be used to effect several motions, and combinations of motion. Some, under the given conditions, would be notoriously inefficient; wasting power, unduly heating the oil causing its eventual breakdown and filling the transmission system with sludge, excessive power consumption due to too large a prime mover, and so forth. All these things eventually will be charged against a machine and can largely be avoided through proper design.

Oil Must Withstand Turbulence

On account of the liming tendencies of ordinary water, with the consequent filling up and corrosion of piping and valves, the rapid wear of operating parts due to sediment, and the impairment of running clearances thereby, oil has largely superseded water as a motive fluid. It is important to obtain an oil which will stand considerable turbulence, sudden changes of high velocity, and what is equally important, the correct viscosity. An oil of excessive viscosity will waste an unbelievable amount of power in a year on account of the inherent friction due to viscosity.

Two important factors having much to do with friction of liquids in motion are viscosity and turbulence due to sudden velocity changes. These should be especially watched. An oil which has given good results from all points involved is obtainable readily under the name "light turbine oil," and has a viscosity of 150 Saybolt seconds at ordinary ambient temperatures. In general, oil thins as the temperature increases, and for good results as regards commercial life, should not be operated at temperatures above 180 degrees Fahr. Where high temperatures are likely to be encountered coolers can be used preferably of the finned tube designs in which the coolant is water, the oil flowing over the outside of the tubes and fins. Prolonged operation at high temperatures will eventually cause sludge deposits, filling the system and necessitating frequent shutdown for cleaning. In aggravated cases solids of a tarry nature are formed, causing valve troubles and possible danger through sticking seats and filled ports, besides the great difficulties of removal of the tar.

The piping necessary to carry the motive fluid from one point to another is preferably of steel; drop forgings or steel castings are advised for high pressures, although cast iron has been successfully used for pressures under 1000 pounds per square inch.

Trouble has been encountered with brass and copper piping and accessories due to the catalytic action of these metals on oil, especially where the temperatures are high. Where brass or bronze parts seem advisable or are dictated for other reasons, the catalytic action can be overcome by tinning the exposed surfaces. Piping for high pressure should be designed by the thick-walled cylinder formulas, not by the common thin cylinder rules. Extra heavy or double

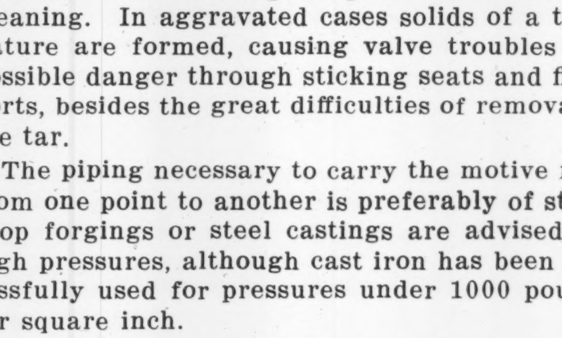


Fig. 1—Primary impulse moves pilot spindle downwards, admitting pressure to cylinder

extra heavy standard pipe will be suitable according to the size and pressure. The size of pipe required depends on many considerations.

Theoretically, maximum power is secured from a given size pipe when the friction loss is one-third the static head with no flow, hence the efficiency of such a system is 66.6 per cent. This results in an appreciable power loss over a year, and the resulting power cost can be capitalized at 6 per cent and balanced against the cost of the system. Better returns on the investment are possible when the pressure loss is about 10 per cent of the static pressure with no flow, with due regard to such particular requirements as an extra large branch for the purpose of rapid acceleration, where such are required.

Gear Pumps Prove Satisfactory

Considering wear of parts, first cost, dependability in general, and nonimpairment of the oil, the writer's experience with gear pumps has been eminently satisfactory. Various forms of cut gear teeth have been used, some authorities preferring one shape, some another. Designers often insists on slightly spiraled teeth, from 3 to 5 degrees with the center line of rotation. However, both straight teeth and spiraled teeth have given excellent results. It is usual to make one gear with one more tooth than the mate, to distribute wear. Clearances, both radial and axial, have an appreciable effect on heating. From 0.002 to 0.005 inch is satisfactory, depending on the size. The shafts should be large in proportion to the power requirements. Excellent results are given by gears cut from 3.5 per cent nickel steel. But pumps of this type are necessarily for variable speed, pressure responsive controls. They do not fulfill all pumping requirements. Many drives require "volumetric" variable stroke pumps in order to realize high efficiency.

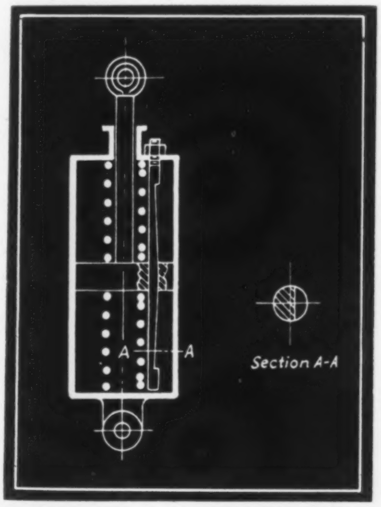


Fig. 2—Dashpot device will give satisfactory results in overcoming hunting tendency

Several highly reliable manufacturers incorporate pressure and, or, quantity control as a built-in feature of the pumping unit. Such controls may be purchased with confidence, as the warranty covering the machine usually applies to the controls with equal force, if not especially so. Commercial parts, backed by tests and careful design and with a large number of successful applications to their credit, can usually be applied with little trouble.

Where trouble usually starts, is where the designer has not been able to secure thoroughly tested commercial parts or devices for the control purposes required and has to start designing special devices for the requirements of his individual machine.

It seems logical to study the application of fluid pressure by a brief analysis of the motions required. Broadly, there are three cases of motion, translation or longitudinal push or pull, rotation, and a combination of translation and rotation according to various laws.

Translation, or reciprocating motion, of high or low velocities of movement, is best accomplished by some form of piston or plunger design. This is also the most efficient form. The piston, if used with clean oil, can be ground to a close fit with its cylinder and where a slight leakage is not harmful, no piston rings are required. For the higher pressures, cup leather designs are practically dictated. Cylinder joints usually are made with male and female doweled faces, with thin paper hydraulic packing. Bolts should not be stressed above 5000 pounds per square inch at the root of the thread, or the stretch begins to be appreciable. Packings for oil is a matter on which there seems diversity of opinion. Both square flax packings and some grades of leather cup shapes have given good results. Oilproof rubber packing is available.

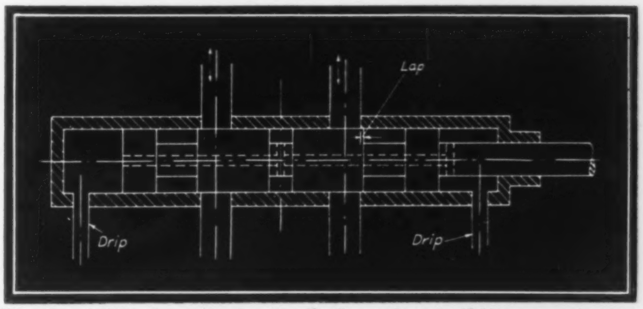


Fig. 3—All leakage is drained off so that building up of pressure does not occur

Combinations of reciprocating and true rotational motion may be secured in a plunger design by milling a portion of the plunger body spirally and having it work in an internally cut spiral collar, having due regard to low bearing pressures for durability.

Pure rotational motion without the nonuniformity due to crank motion may be obtained through small hydraulic turbines geared down to the desired speed. Where machines must operate in hazardous locations, and even explosion-type electric motors cannot be considered, these small geared-down hydraulic turbines make an ideal drive. Efficiencies as high as 70 per cent can be obtained in units as small as 2 horsepower. The advantage of the hydraulic turbine type is that its discharge can be full and backing up against the turbine without harm, as the effective driving pressure is merely the difference between inlet and discharge pressures. An impulse wheel of the Pelton type must have an atmospheric discharge and its efficiencies in small units is likely to be not more than 55 to 60 per cent, notwithstanding the fact that its nozzle design seems very simple and cheap to build.

Under the pressures usually prevalent in hydraulic systems, the speed of the two previously mentioned prime movers may be anything from 3000 revolutions per minute up, according to size, without gearing down. When the high speed suits the purpose these drives are quite in order. For much slower speeds, either gearing down or the use of a gear type rotary motor is in order. The efficiencies of gear type hydraulic motors vary widely according to design; some being as low as 30 per cent in small units. Much better results can be obtained for slow speed drives where multiple cylinder reciprocating motors are used. Their useful life is much longer, which justifies the higher first cost. The variable stroke types give high efficiencies where the load curve varies considerably.

Describes Improved Controls

Controls for automatic operation with time or pressure responsive devices have been slighted in the modern literature of the new hydraulics. *Fig.* 1 shows a valve position restoring device with several useful features. A primary impulse moves the pilot spindle downwards, admitting pressure to the cylinder. For many purposes it is advisable to restore the valve to its original position as the plunger or piston moves toward the end of its stroke. By a suitable linkage the motion of the piston rod restores the pilot spindle to its former position, while the primary impulse gradually moves back. This motion also produces a rapid initial piston movement with a slow final rate. By suitably varying the lever-ratio any desired combination may be obtained, especially when a sliding cam motion can be used to restore the pilot spindle.

In many speed, pressure and electrically operated relays, there will be found a continual hunting or racing for a settled, final position. The dashpot shown in *Fig.* 2 will give satisfactory results in overcoming this. In the particular design shown, the vertical inside rod has a variable damping effect, so that small movements will not allow oil, with which the dashpot is filled, to pass the piston, and so small movements originating in the primary control will not be transmitted to whatever the dashpot damps. In some cases the dashpot may be connected directly between the primary and secondary control, so that the inside rod should have its cut-away portion maximum section directly inside the piston for damping out small chatterings. Each case will require study.

Leakage, particularly with high pressure systems, may cause premature operation of secondary controls. In the type of pilot valve shown in *Fig.* 3, all leakage is drained off so that building up of pressure does not occur. The lap necessary for each case is a matter of judgment. However, for most governing requirements, excessive lap is very harmful and likely to produce constant surging and hunting. For these purposes as little lap as possible is best, with the leakage factor carefully guarded against for building up of pressure and premature operation.

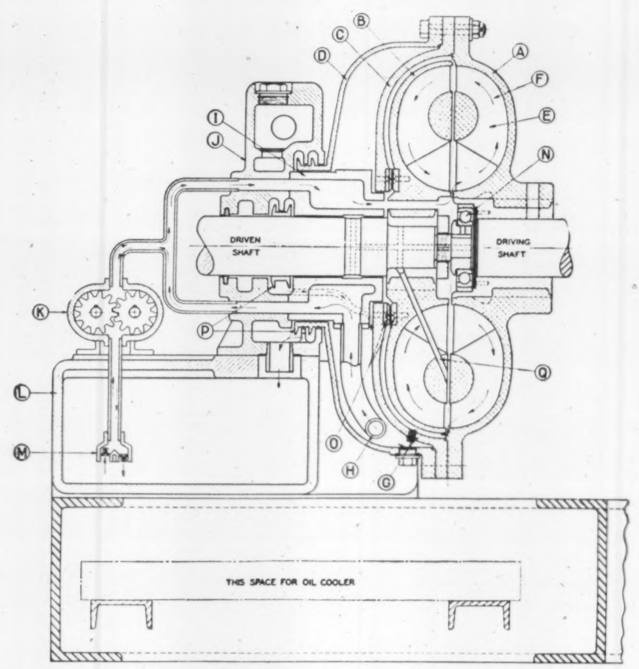
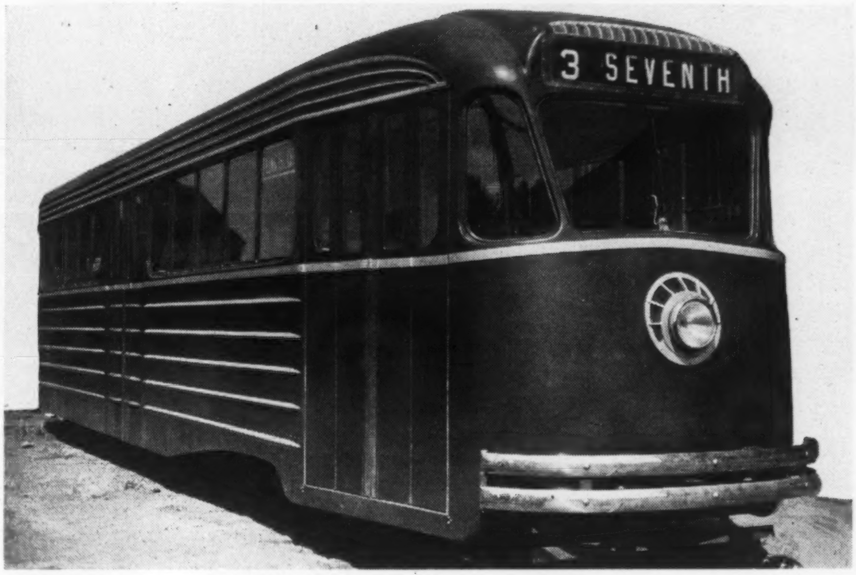


Fig. 4—Hydraulic coupling provides variable speed operation for industrial machinery

It will be found that most controls for automatic operation will be combinations of restoring devices, damping devices and distributing valves. The number of combinations for varied purposes is legion.

In previous articles on the new hydraulics, quite a few types of domestic variable speed drives have been described. There is a new type of an hydraulic coupling already in wide use in Europe, for purposes ranging from absorbing the "kick" of Diesel engines in motorships, eliminating the troublesome clutch in Diesel locomotives, stepless speed control in power plants for fans and stokers, etc. Now made in America, it is offered as a thoroughly modern and efficient speed control for all purposes adapted to its operation. Governor, torque motor and pressure responsive controls can be directly arranged to control the speed of the driven side, through bleeding out or supplying additional oil to the working circuit. *Fig.* 4 shows a cross-section of the coupling, for variable speed operation. This coupling is the industrial component of the device described on page 19 of the April issue of MACHINE DESIGN.

New Designs Demand Improved Steels



By Edwin F. Cone

HIGH-TENSILE, low-alloy steel was used in the construction of this street railway car built by Pullman Car & Mfg. Co. to the specifications of the Electric Railway Presidents' Conference committee of the American Transit association, a group conducting extensive research into the best designs for modern transportation equipment

ONE of the important developments, or trends, in alloy steel metallurgy, which recently has been decidedly emphasized, is a type known as a low-alloy high-tensile steel. A low-cost steel, this material, because of relatively and moderately high tensile strength, can be employed where lightness must be obtained without sacrifice of strength. Such steels usually are used in the "as-rolled" condition; no heat treatment is employed.

More recent demands have involved the development of a steel which should have, besides high strength and elastic limit, excellent welding properties, a reasonable fatigue resistance so that it can be more highly stressed, and also resistance to corrosion in the air. To attain all these properties in one steel is not a simple matter.

This general type of alloy steel—low-alloy, high tensile—is not new, but the tendency to exploit uses and to develop new compositions is new. Some of the more familiar steels of this nature have been known for a number of years. Probably the first one was the well-known 3 to 3.5 per cent nickel steel. Then came the medium-manganese steels, and soon after the high-tensile "silicon" steel followed by the chromium-manganese-silicon steel under the trade name Cromansil. The 1 per cent copper

TABLE I

Properties of 2 Per Cent Nickel Steel, As Rolled

Yield point, lbs./sq. in.	Tensile strength, lbs./sq. in.	Elong. in 8", %	Red. area, %	Izod impact, ft. lbs.	Chemical composition, per cent					
					C	Mn	P	S	Si	Ni
Plate, ⅜-inch:			*For Boiler Plate*							
56,240	81,060	26.0	54.3	....	0.21	0.60	0.011	0.038	0.15	2.07
53.950	80,060	25.0	55.1	....	0.20	0.55	0.014	0.032	0.15	2.17
55,000	81,680	21.0	53 3	....	0.20	0.55	0.010	0.030	0.19	2.17
Plate, ¾-inch:										
48,500	76,000	28.8	59.4	65.0	0.19	0.67	0.018	0.024	0.21	2.16
Plate, ¾-inch:			*For Bridge Plate*							
66,840	106,300	17.8	37.4	....	0.29	1.09	0.025	0.030	0.26	2.01
63,980	104,200	19.5	44.7	....	0.31	1.08	0.040	0.032	0.26	2.04
64,620	99,620	19.5	42.5	....	0.28	1.01	0.042	0.050	0.32	2.12
Plate, 1⅜-inch:			*For Oil Refinery*							
56,700	91,400	21.0	....	....	0.24	0.70	0.018	0.021	0.24	2.35
54,200	85,100	22.0	....	....	0.25	0.60	0.010	0.022	0.22	2.34
50,200	83,100	26.5	....	....	0.23	0.65	0.012	0.021	0.22	2.44
Plate, ½-inch:			*For Ship Plate*							
55,300	88.500	23.0	48.8	70.5	0.26	0.76	0.028	0.033	0.14	2.46
55,300	91,500	19.2	59.5	....	0.21	0.83	....	....	....	2.62
Plate. 11/16-inch:										
54.000	83,500	22.5	53.5	....	0.21	0.82	0.042	0.022	0.24	2.71

TABLE II

Test Results on 3.5 Per Cent Nickel Steels, As Rolled

Size	Carbon, %	Yield point, lbs./sq. in.	Tensile strength, lbs./sq. in.	Elongation, per cent in 2 ins.	8 ins.	Red. of area, %	Izod impact, ft.-lbs.
½-inch Plate	0.32	62,300	101,900	33.5	20.4	47.4	55.5
½-inch Plate	0.32	61,700	102,100	35.5	19.1	44.3	56.5
1½-inch Round	0.40	72,000	110,000	21.0	....	44.0	....
1½-inch Round	0.30	65,000	95,000	24.0	....	46.0	....
½-inch Plate	0.26	56,600	82,000	43.5	25.8	50.7	65.0
1½-inch Round	0.20	60,000	90,000	25.0	....	50.0	....
1½-inch Round	0.20	58.000	85,000	27.0	....	58.0	....
1¼-inch Round	0.20	52,600	80,360	27.3	....	58.5	....

steels also can be included in this classification.

In recent years other low-alloy steels have been placed on the market so that the number has grown to nearly a dozen of varying compositions, properties and claims. In general, these steels can be divided into two classes: Corrosive in the atmosphere; and moderately noncorrosive in the atmosphere.

Tensile strength averages approximately from 75,000 to 100,000 pounds per square inch "as-rolled," with good ductility and high elastic limit. Some of them possess excellent welding properties and fatigue resistance. In general, alloying elements total less than 4 per cent, in some cases much less.

Principal applications at present are for cars, structural use in ships, tanks, boilers and bridges, where lighter structures with increased strength are sought.

The steels to be discussed in this article more or less in the order in which they originate, are: Low-nickel; medium manganese; copper steel (1.25-1.75 per cent); "Cromansil"; chromium-vanadium; carbon-vanadium; manganese-vanadium; manganese-molybdenum; high-"silicon" plus molybdenum; "Cor-Ten"; "Man-Ten"; and "Sil-Ten."

Another steel, said to be under consideration for this class by a large steel company, is a 1.00 to 1.25 per cent copper steel with 0.20 to 0.30 per cent molybdenum. Still another is a 1.25 to 1.75 per cent copper steel with a small amount of nickel.

Presents Nickel Steels

Nickel steels for structural shapes are advocated where a high strength, highly fatigue resistant material of marked toughness and resistance to impact is desired. The higher carbon ranges provide large strength increases over that of ordinary structural steel while the lower carbon ranges offer more moderate strengthening with special emphasis on the toughness and fatigue resisting features.

Two grades of such steel are in general use for structural purposes. One contains about 3.5 per cent nickel with carbon as required; the other, which shows comparable properties and is somewhat cheaper to make, contains a minimum of 2 per cent nickel and a maximum of 1 per cent manganese.

Nickel steel, 3.5 per cent: This grade with 0.30 to 0.40 per cent carbon can be guaranteed to meet the following minimum properties: Yield point 55,000, and tensile strength 85,000-100,000 pounds per square inch; elongation in 8 inches, 18 per cent; reduction of area, 40 per cent; and Izod impact value, 40-60 foot-pounds.

Table II shows test results on this steel in the as-rolled condition, data being from the records of the International Nickel Co. Inc., New York.

The 2 per cent nickel steels: Some test results on the lower nickel grade in "as rolled" plate are found in Table I, which is published on page 31.

TABLE III

Physical Properties of Cromansil Steels

Plate size, inches	Per cent C	Cr	Mn	Si	Yield point, lbs./sq. in.	Tensile strength, lbs./sq. in.	Elong. % in 8 in.	Red. of area, %	Brinell hardness	Izod impact, ft.-lbs.
¾	0.09	0.48	1.47	0.54	48,000	75,000	30.0	61.0	150	....
¼	0.15	0.23	1.26	0.78	62,000	85,000	21.0	....	......	....
⅜	0.20	0.49	1.27	0.92	67,000	95,000	20.0	44.0	200	....
¾	0.20	0.49	1.27	0.92	63,000	98,000	21.0	52.0	200	....
1½	0.20	0.49	1.27	0.92	68,000	96,000	21.0	52.0	200	....
½	0.21	0.47	1.17	0.72	50,000	92,000	20.0	56.0	210	36
1	0.21	0.47	1.17	0.72	51,000	99,000	16.0	....	210	25
1½	0.21	0.47	1.17	0.72	56,000	89,000	19.0	....	210	24
2	0.21	0.47	1.17	0.72	53,000	86.000	20.0	....	210	20
½	0.21	0.62	1.24	0.71	56,000	87,000	21.0	55.0	185	....
1	0.26	0.52	1.10	0.74	59,000	96,000	28.0*	63.0	......	....
¾	0.30	0.45	1.39	0.86	65,000	114,000	20.0*	47.0	230	....
¾	0.39	0.50	1.41	0.81	67,000	128,000	16.0	43.0	270	....
⅜	0.46	0.67	1.19	0.82	91,000	143,000	19.0*	....	270	20

*Per cent in 2 inches.

Both grades of nickel structural steel are amenable to heat treatment when even better combinations of properties are required. The 0.30 to 0.40 per cent carbon, 3.5 per cent nickel steel, oil quenched and drawn at 1000 degrees Fahr., will approximate the following values: Yield point 88,000, and tensile strength 115,000 pounds per square inch; elongation in 8 inches, 20 per cent; reduction of area, 60 per cent; and Izod impact value, 70 foot-pounds.

Recently considerable work has been done in regard to the welding of these nickel steels. As a result, there are now several commercial welding rods on the market.

The so-called "medium" or "intermediate" manganese steels have become widely used in recent years. They range from 1.00 to 1.75 per cent manganese with varying percentages of carbon (0.10 to 0.70 per cent). Tensile strengths average from 85,000 to 120,000 pounds per square inch, with yield points from 65,000 to at least 90,000 pounds per square inch after heat treatment. The ductility of some of the steels of this type is excellent.

The application of these steels has been confined largely to heat treated products such as forgings. One automobile company employs these types exclusively in many of its alloy steel parts.

In the "as-rolled" condition, these steels have found some use but not to the extent of some of the other low-alloy steels. A steel of this class (0.30 per cent carbon and 1.50 per cent manganese) has approximately a yield point of 60,000 pounds per square inch and a tensile strength of 95,000 pounds per square inch with an elongation in 2 inches of 24 per cent and a reduction of area of 55 per cent.

The copper (low-alloy) steels are neither so well-known nor so extensively used as some of the other steels. It is known that additions of copper from 0.50 to 1.75 per cent enhance the physical properties, particularly the tensile strength, of plain carbon steels. These steels have not yet been commercially tested and applied in the as-rolled condition to any extent but their investigation is proceeding rapidly. Where surface finish is a prime consideration, there are usually added small percentages of nickel with the copper. It is expected that the 1.25 to 1.75 per cent copper steels (with nickel) will be heard from in the growing competition among the low-alloy high-tensile steels.

TABLE IV

Average Physical Properties of Chrome-Vanadium Steel Plates After Annealing

Carbon, per cent	Plate thickness, in.	Tensile strength, lbs./sq. in.	Yield point, lbs./sq. in.	Elong., % in 8"	Red. of area, %
0.25	1½	104,000	70,000	18	50
0.25	¾	124,000	80,000	15	40
0.15	¾	85,000	55,000	20	55
0.15	⅜	....	58,000	20	55

Cromansil steel—named from its three principal alloying ingredients, chromium-manganese, and silicon—was developed by the Electro Metallurgical Co., New York, to replace carbon steels in applications where a steel having a combination of high strength and good ductility in the as-rolled condition is required.

In general, the composition of Cromansil steel has the following range:

	Per Cent
Chromium	0.40–0.60
Manganese	1.10–1.40
Silicon	0.60–0.90

The carbon content may be varied, depending on the physical properties desired and the thickness of the section. For general use, when this steel is to be cold-worked, machined or welded, the most satisfactory results have been obtained with a carbon of 0.15 to 0.25 per cent. Actual commercial test results of Cromansil steels are given in Table III. These give a comprehensive idea of the possibilities claimed for these steels of varying compositions.

Fatigue Limits Given

Tests made in a Farmer rotating-beam testing machine show that this steel has a fatigue limit of 50 to 60 per cent of the ultimate tensile strength while for plain carbon steel it is only about 40 to 50 per cent. Other tests show that Izod impact values per square centimeter range from 20 to 64 foot-pounds depending on the size of the section examined.

In the low-alloy high-tensile field there are three principal compositions, carbon-vanadium, chromium-vanadium, and manganese-vanadium steels.

Carbon-vanadium steel: This type of steel is not as extensively used in the as-rolled condition for structural applications as the chromium-vanadium or manganese-vanadium steels. One of its principal applications is for large hammer welded tanks. It has decidedly enhanced physical and other properties compared to those of plain carbon steel. In the as-rolled condition, at other than excessive temperatures, this steel exhibits a finer and more uniform grain size than similar steels not containing vanadium.

In composition, this steel corresponds to the usual carbon plate and structural steels, with the addition of from 0.10 to 0.18 per cent vanadium. The range in physical properties in the as-rolled condition for plates with about 0.20 per cent carbon and manganese 0.45 to 0.75 per cent would be, depending upon the percentage of

TABLE V

Properties of Low-Alloy Molybdenum Steels, As Rolled

Manganese-Molybdenum

Chemical composition, % C	Mn	Si	Mo	Plate, in.	Yield point, lbs./sq. in.	Tensile strength, lbs./sq. in.	Elongation, % in 8"
0.13	0.90	0.21	0.48	15/16	48,400	75,350	27.0
0.16	0.78	0.19	0.46	¾	49,000	78,900	25.0
0.10	1.05	0.21	0.42	½	54,500	76,200	21.0
0.15	1.59	0.42	0.35	½	66,850	98,760	15.0

Charpy impact tests of the first two steels were 20 foot-pounds as-rolled and 35 foot-pounds normalized.

"High-Silicon" with Molybdenum

—Chemical composition, %— C	Mn	Si	Mo	Cu	Plate, in.	Yield point, lbs./sq. in.	Tensile strength, lbs./sq. in.	Elongation, % in 8"
0.28	0.86	0.22	0.22	....	⅜	56,720	88,260	19.75
0.32	0.77	0.26	0.20	0.27	¾	56,190	89,400	20.20
0.33*	0.87	0.29	....	0.26	½	48,030	86,030	20.60

*Standard "silicon" bridge steel.

vanadium present and thickness of the plate, as follows:

Tensile strength	65,000–75,000 lbs./sq. in.
Yield point	40,000–50,000 lbs./sq. in.
Elongation, 8 inches	30–20 per cent
Reduction of area	60–50 per cent
Brinell hardness	126–146

Chromium-vanadium steel: This steel has found its principal use in the as-rolled condition as plates for electrically welded tanks for transporting gases under pressure, and electrically welded reaction chambers for chemical and oil industries.

The composition of this type of vanadium steel in general use for such purposes corresponds to S. A. E. 6120 steel, ranging from 0.15 to 0.25 per cent carbon, 0.80 to 1.10 per cent chromium, 0.50 to 0.80 manganese, and 0.15 minimum vanadium. Electrically welded tanks and vessels are usually given an annealing treatment at about 1150 degrees Fahr. The physical properties of chromium-vanadium plates after such an annealing would have about the average values shown in Table IV which is presented on page 33.

TABLE VI

Properties of Special High-Tensile Steels

Chemical:	Regular open-hearth	Cor-Ten	Man-Ten	Sil-Ten
		Per cent		
Carbon	0.10	0.10	0.35	0.40
Manganese	0.50	0.10-0.30	1.25-1.70	0.70-0.90
Phosphorus	0.04	0.10-0.20	0.04	0.04
Sulphur	0.05	0.05	0.05	0.05
Silicon	0.10	0.50-1.00	0.15*	0.20-0.30
Copper	0.20**	0.30-0.50	0.20**	....
Chromium	......	0.50-1.50	....	....

*Maximum, if no range or other limit is indicated.
**Minimum, if copper is specified.

Physical:	Regular open-hearth	Cor-Ten	Man-Ten	Sil-Ten
Yield point, lbs./sq. in.	25,000-35,000	50,000-60,000	55,000-65,000	45,000
Tensile strength, lbs./sq. in.	35,000-50,000	65,000-75,000	80,000-90,000	80,000-95,000
Elongation in 2 in., per cent	34-25	27-22	25-20	23-18
Izod impact, ft.-lbs.	30	60	40	....
Endurance limit, lbs./sq. in.	25,000	45,000	40,000	....

Modulus of elasticity—28,000,000-30,000,000.
Impact and endurance values only approximate.
Ranges of physical properties are minima and cover possible sheet treatments.
Regular open-hearth included only for comparison.

Manganese-vanadium steel: This steel, which is the most important of the low-alloy high-tensile steels in the as-rolled condition, is a low-carbon medium-manganese steel to which a small percentage of vanadium has been added. Its principal application has been for structural plates and shapes. Typical of the specifications for this steel are those recently issued by the navy department:

	Per Cent
Carbon	0.18 max.
Manganese	1.45 max.
Silicon	0.25 max.
Sulphur	0.25 max.
Phosphorus	0.04 max.
Vanadium	0.08 min. to 0.18 max.
Copper	0.20 max.

Plates ranging from ½-inch to ¾-inch in thickness to the above chemical limits will show the following physical properties:

Tensile strength	80,000 lbs./sq. in., min.
Yield point	50,000 lbs./sq. in., min.
Elongation in 8 in.	20 per cent, min.

The steel also has high impact and endurance values. It has excellent welding qualities, and welds retain the inherent toughness of the steel to a remarkable extent, according to the Vanadium Corp. of America, New York, from which this information was obtained.

As in the case of vanadium, there are two low-alloy high-tensile steels containing molybdenum —manganese-molybdenum and carbon-molybdenum. In composition they are similar. There is also a so-called "high-silicon" steel to which molybdenum is added.

Manganese - molybdenum: The most interesting and important of these low-alloy molybdenum steels is the manganese-molybdenum. It is pointed to by the Climax Molybdenum Co., New York, as "a finely weldable, high-strength structural steel of exceptional grade and utility."

Physical properties and analyses, selected from records of basic open-hearth heats and reproduced in Table V, are indicative of the possibilities of this steel.

"High-silicon" with molybdenum: By adding about 0.25 per cent molybdenum to the "high silicon" (yield point 45,000 pounds per square inch minimum), a steel is claimed which is as easily produced but more easily fabricated than the silicon steel. It is "a reasonable cost, most dependably satisfactory high-strength bridge steel and is recommended for all riveted rather than welded construction in which properties of this character are desired." Commercial test results are shown in Table V.

Carbon-molybdenum: This steel is a plain medium or low-carbon steel containing about 0.20 to 0.30 per cent molybdenum. While this grade has not yet been used commercially as a structural steel, it is pointed to as capable of meeting the general specifications for the low-alloy high-strength steels.

Another molybdenum steel which is expected to come under the general classification discussed in this article is the copper-molybdenum type. The molybdenum in this grade ranges from 0.20 to 0.30 per cent with the copper either 0.30 to 0.50 per cent or as high as 1.25 to 1.75 per cent with the carbon in low range.

(*Concluded on Page* 69)

Meeting Special Conditions in Conveyors

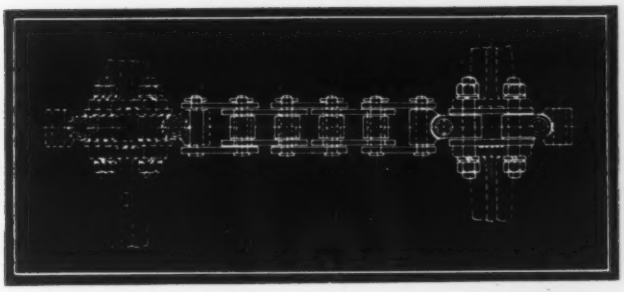


Fig. 1—Universal joint designed into chain permits lateral flexibility

By E. Arentzen

Chief Engineer, Joy Mfg. Co.

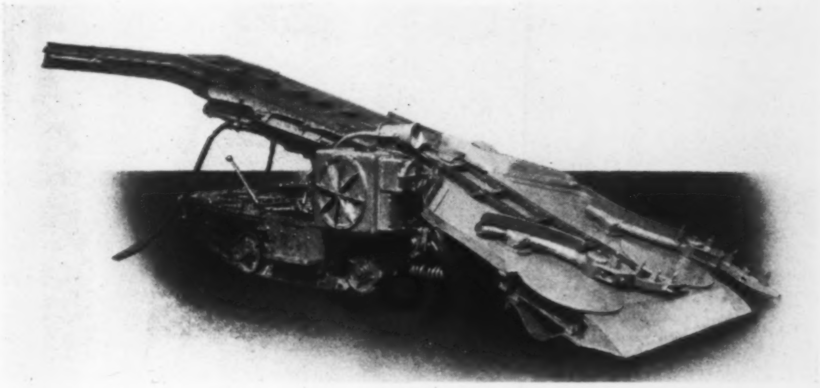


Fig. 2—Coal loader is designed to be low in height and yet deliver coal at points forty-five degrees from its center line

IN DESIGNING most machines the engineer is concerned about size only as it affects compactness of the machine and limits the placing of interior mechanisms. But in machines to be used in mines, size plays an even more important role. In mines space is always limited, and large machines must often operate in areas where it is impossible for a man to stand erect. Also, the head room in the mines, dictated by the thickness of the vein, varies to a considerable degree.

It is just such conditions that might militate against the use of some excellent machines simply because of their size. For example, Joy Mfg. Co. has for some years been manufacturing a hydraulic coal loader and conveyor. This conveyor, described in the article by John Merck on page 19 of the August, 1930, issue of MACHINE DESIGN, was, and still is an efficient mechanism. In its operation gathering arms bring the coal to the base of a conveyor which carries the material to a point approximately midway back where it is dumped at the foot of a second conveyor. The second unit raises the coal and carries it to cars. This design permits the facing of the loader directly into the coal vein yet loading on cars at 90 degrees either side of the machine.

In order to supply those mines where the height of this first machine was too great to permit its use, and to simplify the construction, the Joy company decided to build an additional model, *Fig.* 2. As the use of two conveyors, one dumping into another, required precious height, this mode of transference was not suited to the conditions. However, it was extremely desirable to maintain a considerable swing at the discharge end in order to facilitate loading.

The problem of height could be solved by the use of a single conveyor, but the discharge swing was another matter. As the conveyor must be power driven and must raise the coal over the side of the car, a positive, laterally flexible conveyor was the only solution.

The first necessity for a flexible conveyor are flights that will go around a corner. Alloy steel chain of 2-inch pitch equipped with special side bars, *Fig.* 1, forms the basis for these flights. The flights themselves are forged steel arms, spaced 14 inches apart. Flexibility is provided by universal joints at each flight, *Fig.* 1, which in themselves would permit the flights to be turned 90 degrees with regard to the center line of the chain as well as permitting them to follow the chain in its forward travel around the end of the conveyor and the drive sprocket. Studs used in these universal joints are 5 per cent nickel steel, adopted to protect the conveyor against unusual strains.

Power for the conveyor is taken from the same shaft that actuates the primary conveyor in other models. This eliminates the second driving unit required for a second conveyor. However, the sprocket to be used presented a problem. It was necessary that the flights follow the chain around this sprocket, yet the design of the universal joints would not permit their meshing. This difficulty was overcome by the proportions of the conveyor and by the use of an even tooth sprocket, every other tooth of which is cut out, permitting the flights to fit into this opening without interfering with meshing of the chain.

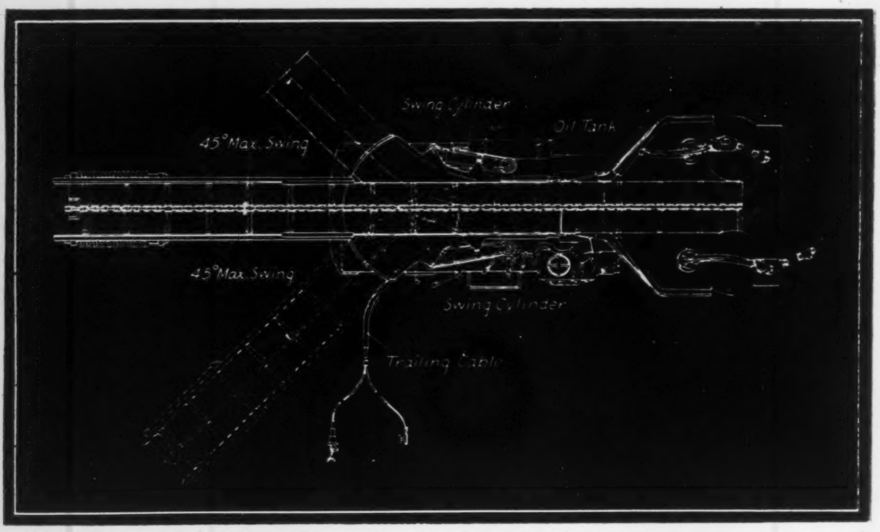


Fig. 3—Employment of new conveyor system eliminates the necessity for a second driving unit

Having obtained a chain that would go around a corner, it was next necessary to design a conveyor trough that would be possible of adjustment to the exact position of the car, and one which would lead the flights and the coal carried through this angle to the car. This is accomplished by a fish tail arrangement. The forward portion of the conveyor trough terminates in a sector over which the conveyor may travel, *Fig.* 3. Pivoted on the center line of this section is the second portion of the conveyor which can be swung from side to side riding on the arc of the sector and supported by the structure. Swinging of the tail is by hydraulic power, two cylinders located one on either side being used. As oil is forced into one of these cylinders to pull the tail around, valves are opened in the other and the oil forced out.

Swinging of the tail solved the problem of meeting the comparative angular position of cars, but it introduced the problem of guide rails to get the conveyor flights around the corner created. Rails of spring steel which form an arc when the tail is swung around are employed. These spring steel pieces are riveted in place at the lower end. At the upper end they are restrained from sideways motion by U-shaped pieces riveted to the side bars of the tail section. These pieces do not limit longitudinal length of the spring steel bars. When the tail piece swings and an arc is created, the spring bars slip lengthwise to adjust themselves to the new distance, shorter or longer around the arc, created by the change in position.

This arrangement permits conveying the coal through a swing of 45 degrees either side of the machine, a swing which, though not as great as that of the loader described in August, 1930, is ample for a great many purposes.

In order to reduce the friction which the travel of the flights around the corner might create, rollers are placed at the end of each flight to ease their movement whenever they contact the side bars.

As distance traveled by the conveyor changes when the tail is swung away from the center line of the machine, it was necessary to provide a compensating arrangement so that tension on the chain would be sufficient to carry the coal at all times. This compensating arrangement is two compression springs, located on either side of the end piece on the tail section. The end piece itself is a separate part so arranged that it will slip under the trough to the tail section. When the distance along the conveyor from forward to rear ends of the trough changes, these springs, tending to force the end piece out, will adjust it so that the proper tension is always available.

Mechanisms Are Protected

The springs also assist in protecting the machine against damage. In the event that coal should block between the roof of the mine and the trough, there is a degree of flexibility that enables a momentary pause without breaking the conveyor. Another factor contributing to this protection is that the flights through the universal joints can swing at an angle to the line of conveyor travel. However, in order to prevent any possibility of jamming and breakage, a slip clutch has been built into the drive. This clutch is made up of a series of plates running in oil, the plates being held in contact by a spring that will give before breakage of parts in the event of a serious "roofing" of coal.

New Machines Indicate Design Trends

TO THE uninitiated it might appear that new machines are brought out with machine-gun rapidity. This, of course, is not true. Many an engineer can testify to the weeks, months and even years that he has sat up with a design, revamping here, rebuilding there until the final finished machine was ready to be introduced.

Through all of this process the intimate interchange of ideas is paramount. Designers of mammoth presses may even obtain ideas from sewing machines. The most obvious example of how this study will advance the acceptance of a mechanism or part that will improve operation or reduce costs is found in the rapid spread of antifriction bearings. At one time these parts were employed only in precision equipment, but today one finds them used universally in machinery from road rollers to instruments.

Machines recently announced in addition to those on the next two pages include the following, arranged by fields of application:

Automotive

Six Cylinder Gasoline Engine,
Hercules Motor Corp.,
Canton, O.

Chemical

Small Colloid Mill,
Chemicolloid Laboratories Inc.,
New York.

Sulphur Pump,
Hills-McCanna Co.,
Chicago.

Cleaning

Automatic Crown Ironer,
Cleaners Appliance Co.,
Des Moines, Ia.

Construction

Dragline,
Harnischfeger Corp.,
Milwaukee.

Two-Stage Portable Compressor,
Schramm Inc.,
West Chester, Pa.

Wagon Drill,
Worthington Pump & Machinery Corp.,
Harrison, N. J.

Road Roller,
Hercules Co.,
Marion, O.

Power Driven Road Finisher,
Blaw-Knox Co.,
Pittsburgh.

Portable Gasoline Hammer,
Barco Mfg. Co.,
Chicago.

Domestic

Automatic Water Heater,
General Electric Co.,
Cleveland.

Washing Machine,
Voss Bros. Mfg. Co.,
Davenport, Ia.

Ironer,
Fairbanks-Morse Home Appliances Inc.,
Chicago.

Foundry

Core Machine,
Wm. Demmler & Bros.,
Kewanee, Ill.

Gyratory Screen,
Beardsley & Piper Co.,
Chicago.

Sand Mixer,
Lancaster Iron Works Inc.,
Lancaster, Pa.

Industrial

Portable Elevator,
Barrett-Cravens Co.,
Chicago.

Safety Balancer,
Chicago Pneumatic Tool Co.,
New York.

Tractor,
Clark Tructractor Co.,
Battle Creek, Mich.

Air Filter,
C. O. Bartlett & Snow Co.,
Cleveland.

Portable Electric Blower, Sprayer and Suction Cleaner,
Clements Mfg. Co. Inc.,
Chicago.

Puller-Hoist,
Edelblute Mfg. Co.,
Reynoldsville, Pa.

Heavy Duty Truck Scales,
Bonded Scale Co.,
Columbus, O.

Metalworking

All Steel Totally Enclosed Shear,
Beatty Machine & Mfg. Co.,
Hammond, Ind.

Lathe Converter,
Master Brake & Appliance Co.,
Trousdale, Kans.

Small Type Mult-Au-Matic,
Bullard Co.,
Bridgeport, Conn.

Cemented Carbide Grinding and Finishing Machine,
Ex-Cell-O Aircraft & Tool Corp.,
Detroit.

Scrap Metal Bailing Press,
Hydraulic Press Mfg. Co.,
Mount Gilead, O.

Hydraulic Forcing and Broaching Press,
Logansport Machine Co.,
Logansport, Ind.

Motor Driven Hand Shear,
Stanley Electric Tool Co.,
New Britain, Conn.

High-Speed Floor Grinder,
Bridgeport Safety Emery Wheel Co.,
Bridgeport, Conn.

Mining

Conveying Equipment,
Wilmot Engineering Co.,
Hazleton, Pa.

Moving Picture

16 mm Projector,
Bell & Howell Co.,
Chicago.

Office

Electric Comptometer,
Felt & Tarrant Mfg. Co.,
Chicago.

Rotary Stencil Duplicator,
Post-O-Graf Inc.,
Wilkes-Barre, Pa.

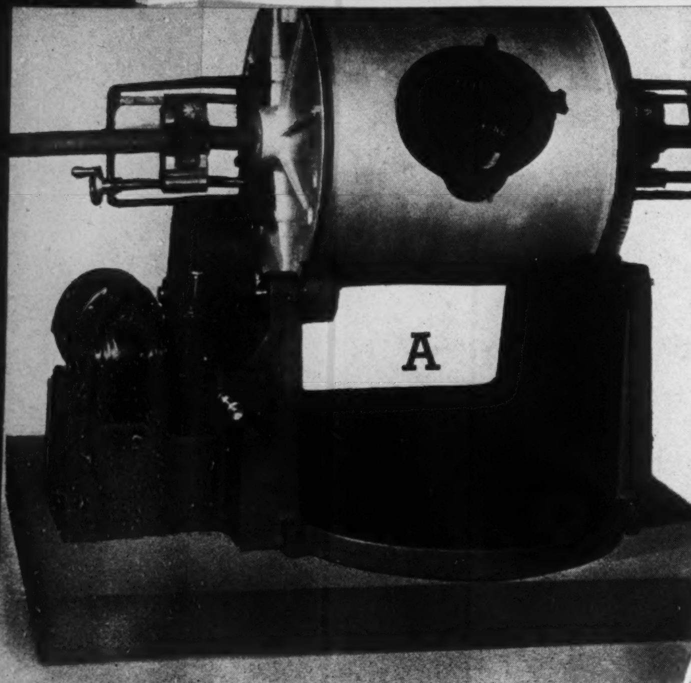
Printing

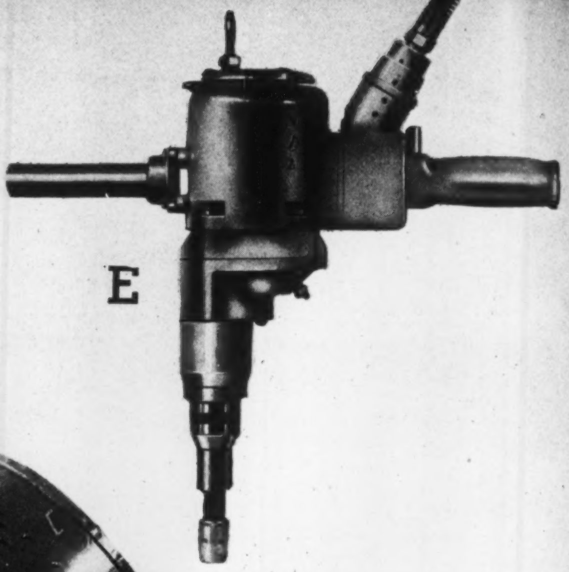
Bench Type Saw Trimmer,
Printers' Equipment Mfg. Co.,
Toledo, O.

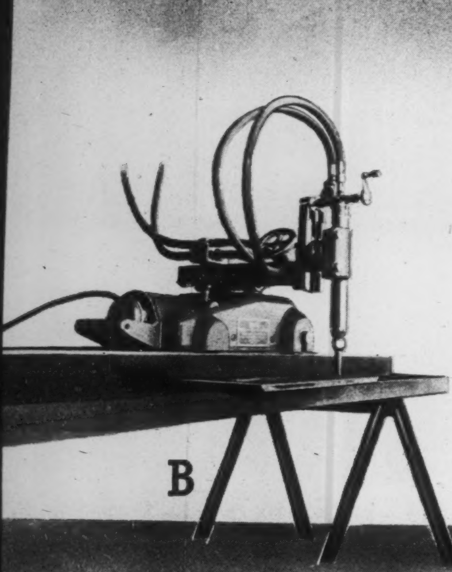
Welding

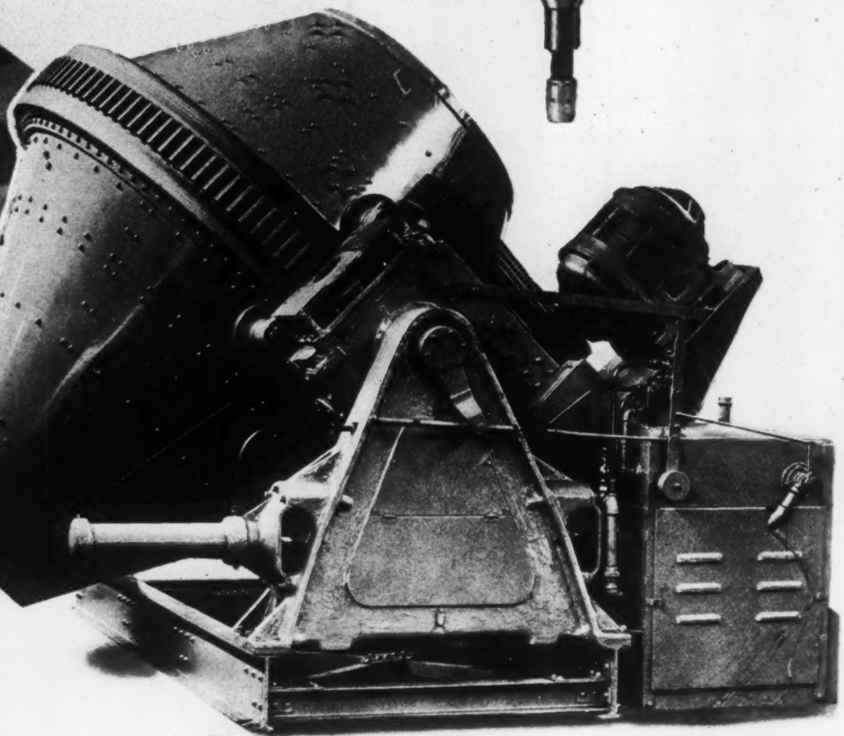
Alternating Current Welder,
Lincoln Electric Co.,
Cleveland.

Seam Welder,
Thomson-Gibb Electric Welding Co.,
Lynn, Mass.









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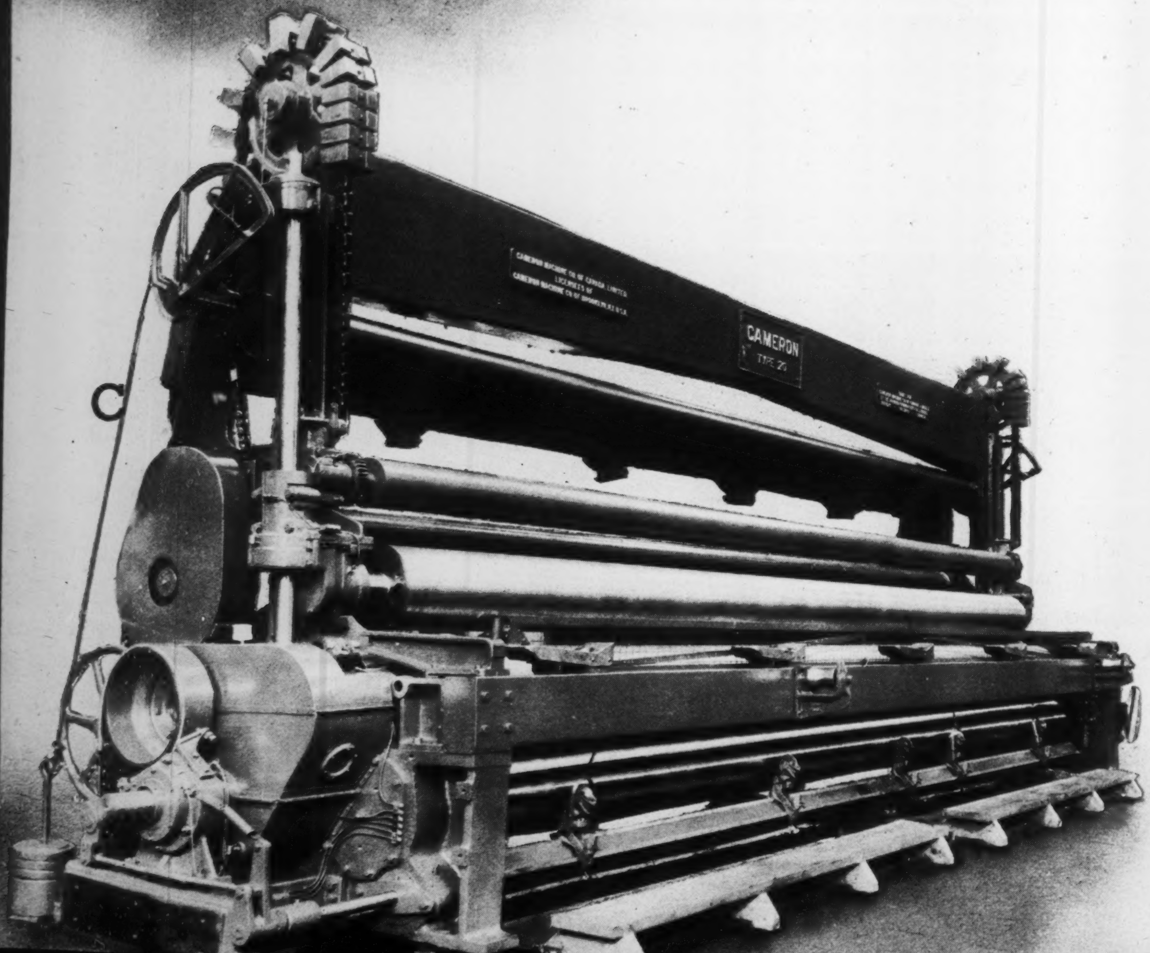


(A) Special rocking mechanism on this
melting furnace is arranged so that th
velocity is zero at the point of reversal desp
fact that a constant speed motor is used.
machine, built by Detroit Electric Furnace Co
of rock is increased automatically.

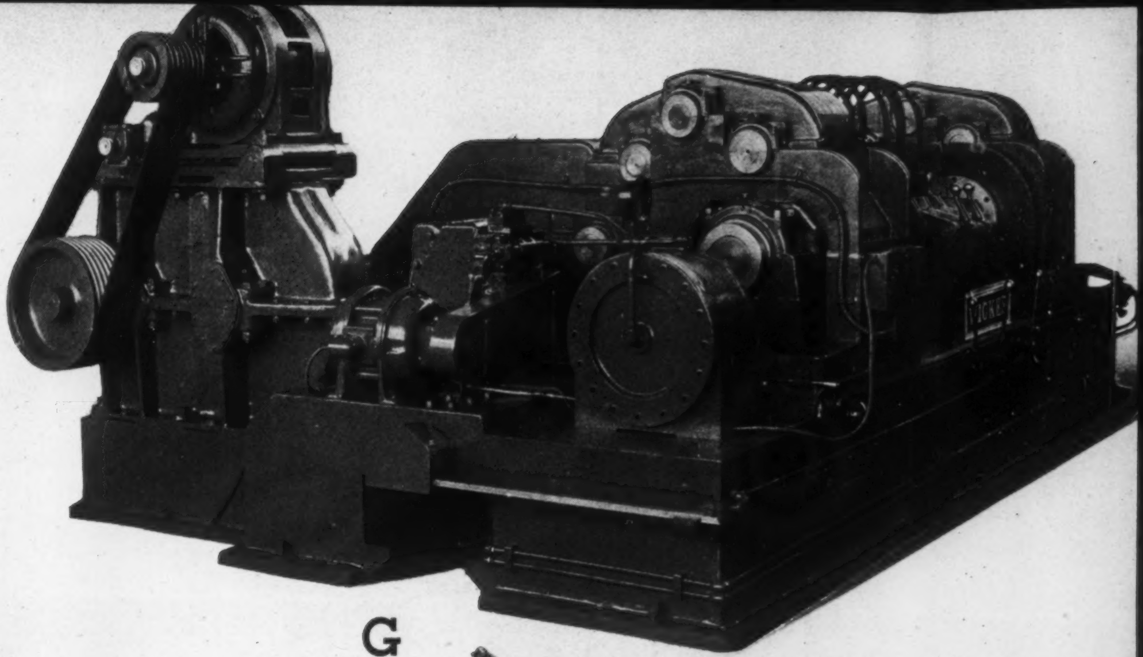
(B) "Streamlined" to facilitate both operati
maintenance, the new oxyacetylene
machine of Linde Air Products Co. has all w
elements enclosed in a double cover. Location
speed regulator near the guiding handle p
simplification of control. Any speed within the c
of the machine is obtained by merely setting
dicator and shifting the gear handle.

(C) Seamless steel tubing is used for winding
compensating roll, riding roll and web
rolls on large paper winder of Cameron Machi
This machine, which runs without vibration
feet per minute, uses roller or ball bearings throu
An automatic counterweight device provides a
riding roller pressure at the start and decrease
sure as weight of rewound roll increases.

(D) Motor of tilting mixer is mounted on th
ing frame with the power transmitted
reduction unit, also mounted on the tilting
by means of V-belt drives. Tilting of the d
accomplished by means of either an indep
pneumatic or hydraulic tilting mechanism.
machine is built by T. L. Smith Co.

(E) Improved nut runner of Buckeye Portabl
Co. has a shockless feature which cent
a clutch arranged with an adjustable releasin
to trip the clutch open when the nut is brought
tight. Operation does not depend on friction
drive; when the cam operates the tool runs free.

F



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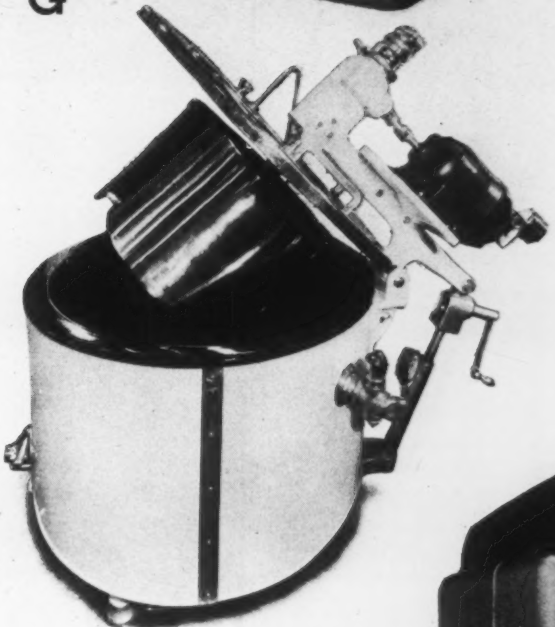

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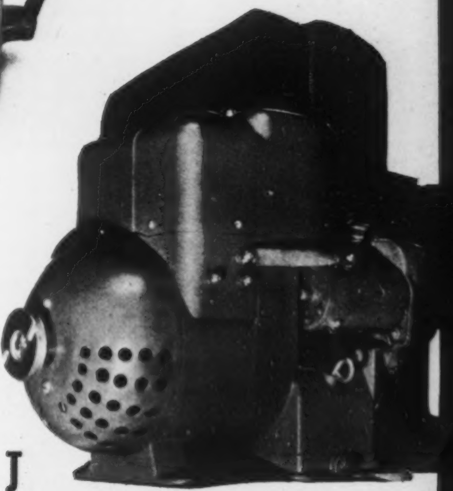

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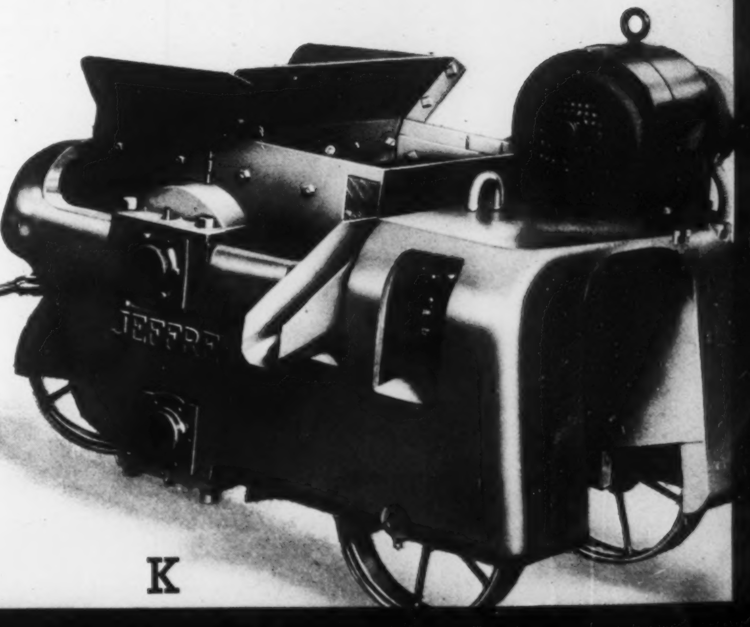

K

Design Features in New Machines

A Pictorial Presentation of Recent Machinery from the Standpoint of Design.

m on this electric
d so that the shell
eversal despite the
r is used. In this
Furnace Co., angle

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yacetylene cutting
o. has all working
r. Location of the
handle provides
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for winding drums,
ll and web guide
eron Machine Co.
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ransmitted to the
he tilting frame,
of the drum is
an independent
echanism. The

eye Portable Tool
which centers in
le releasing cam
is brought down
n friction in the
l runs free.

(F) Quiet operation was achieved in this General Electric washer by reducing the number of moving parts in the gearcase to four—a worm and gear and a rack and pinion—by specifying close tolerances, and by proper proportioning of design. Gear drive is enclosed in a zinc die-cast case. Motor is insulated by rubber bushings. Pump is of friction-driven centrifugal type.

(G) Steel, fabricated by welding is employed for the base of new contour turning lathe built by Wickes Brothers. The machine is driven by means of a 30-horsepower constant speed motor through a speed reducer. Separate motors, built into the machine, are used for the hydraulic pumps and cooling compound.

(H) Vertical revolving helical heat exchanger coils have been replaced by a revolving Thermo-Drum in the pasteurizer of Pfaudler Co. Tinned copper, Inconel or stainless steel drums are available. The drum is suspended from the cover of the vat and the entire assembly can be elevated for cleaning.

(J) Pressure feed oiling through the crankshaft is employed in the streamlined electric lighting plants of D. W. Onan & Sons. Pistons and connecting rods are aluminum while the engine is dynamically balanced to eliminate vibration. All parts are standard either to the automotive or electrical field.

(K) A positive, eccentric type vibrating screen is used on new portable sand conditioner of Jeffrey Mfg. Co. One V-belt from the motor, mounted on the unit, is the only driving part in the entire machine. Control is by push buttons. Safety is insured by a cast aluminum guard over the V-belt drive. Wheels are mounted on roller bearings. The frame is a one-piece steel casting.

MACHINE DESIGN

Development and Design Stand Best Chance in Subnormal Periods

MANY authorities claim that design progresses faster in depression years than during normal times. This is true, especially when consideration is given to the fact that many designs stay on the board or are pidgeon-holed when completed, pending the most opportune time for production.

The year now passing furnishes concrete evidence in corroboration. How many decades must one go back to see the same amount of development in transportation equipment—particularly trains—as has been witnessed during 1934? And during what period has the design of diesels, used on these trains and in many other new places, shown as much progress? Yet research and development in both of these lines has been under way for years.

Another field in the same category is refrigeration and air conditioning—though here it is more a case of new design than redesign. Similarly with the introduction of machinery and appliances for the home and for packaging. Engineering departments of the companies in these fields have been, and still are, hard at work creating new designs and redesigns as rapidly as conditions will permit.

Given as much improvement in general business in 1935 as in 1934, other more or less revolutionary developments will come to light. And the time for engineering to be completed on these is now, while there still is time to take a deep breath!

• • •

Fundamentals of Style

AT THE risk of seeming repetitive, stress should be laid on the fact that machinery is having its face lifted! Work of the "industrial designer" is being recognized more and more; his influence is seeping—probably unwittingly in many cases—into the minds of all alert machine designers.

Dreyfuss, Teague, Van Doran, Switzer and numerous others must be credited with having had a hand in furthering the changing idea of style in machinery. They have not competed with the mechanical engineer; rather they have been the means of creating a consciousness of the maxim that without a strong semblance of "art" in its design a machine built for sale has small chances of success.

But what are the fundamentals of this new concept? The subject has been touched upon by MACHINE DESIGN many times in the past. An entirely different type of presentation is planned, however, for a series of two articles to commence in an early issue. In this series will be outlined the fundamental principles upon which appearance in design is based. The two contributions should be worthy of the close attention of progressive engineers.

PROFESSIONAL VIEWPOINTS

Machine Design Welcomes Letters Suitable for Publication

Calculating Shrink and Press Fits

To the Editor:

MAY I submit a handy alignment diagram solution of most cases of shrink and force fits? It is based on the Lame thick cylinder theory, for the special cases in particular where the inner cylinder becomes a solid shaft. In the diagram, (page 42), solutions of bushing problems are possible with sufficient accuracy.

If the fit allowance per inch of diameter of shaft or bushing is represented by d/D and the modulus of elasticity of the compressing member material by E, the maximum hoop or tensile stress for a hub of indefinitely small thickness is

$$S = (d/D)E \text{ pounds per square inch}$$

As the thickness of hub increases, this maximum stress decreases until when t, the hub thickness, becomes infinitely great compared to r, the radius of the shaft, the maximum stress is half of that found by the above formula for steel hubs on steel shafts and 0.62 of the above result for cast iron hubs on steel shafts. The diagram shows very well how little the hoop stress decreases for a large increase of hub thickness. But the gripping pressure on the shaft increases rapidly for a given value of d/D.

On the diagram a solution is shown for a fit allowance of 0.001 inch per inch of diameter, a t/r value of 0.5, giving for a cast iron hub on a steel shaft a maximum hoop stress of 11,000 pounds per square inch, which by the way is high for that material on steel.

Stresses of 12,000 pounds per square inch for steel on steel give good force fits. Stresses in cast iron usually should not exceed about 4000 pounds per square inch.

—JOHN S. CARPENTER,
Detroit

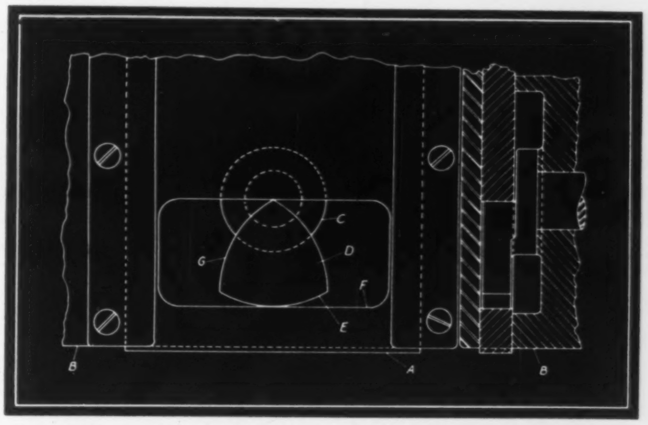
Intermittent Movement Is Positive

To the Editor:

A MODIFICATION of the well known Scotch yoke, in which the crank pin is designed to give a dwell to a slide at both ends of its stroke, is shown in the accompanying illustration. This arrangement is used in a shell marking machine for imparting a positive intermittent movement to the work dial (not shown).

Slide *A* travels in guides on machine frame *B* and receives its motion from crank *C*. Crank pin *D* is of triangular shape and engages an elongated slot in the slide. An important requisite is that the distance between two parallel lines tangent to opposite sides of the crank pin remain constant regardless of the angular position of the pin. To obtain this condition, the curvature of each side is made to coincide with an arc struck with the oposite corner as a center.

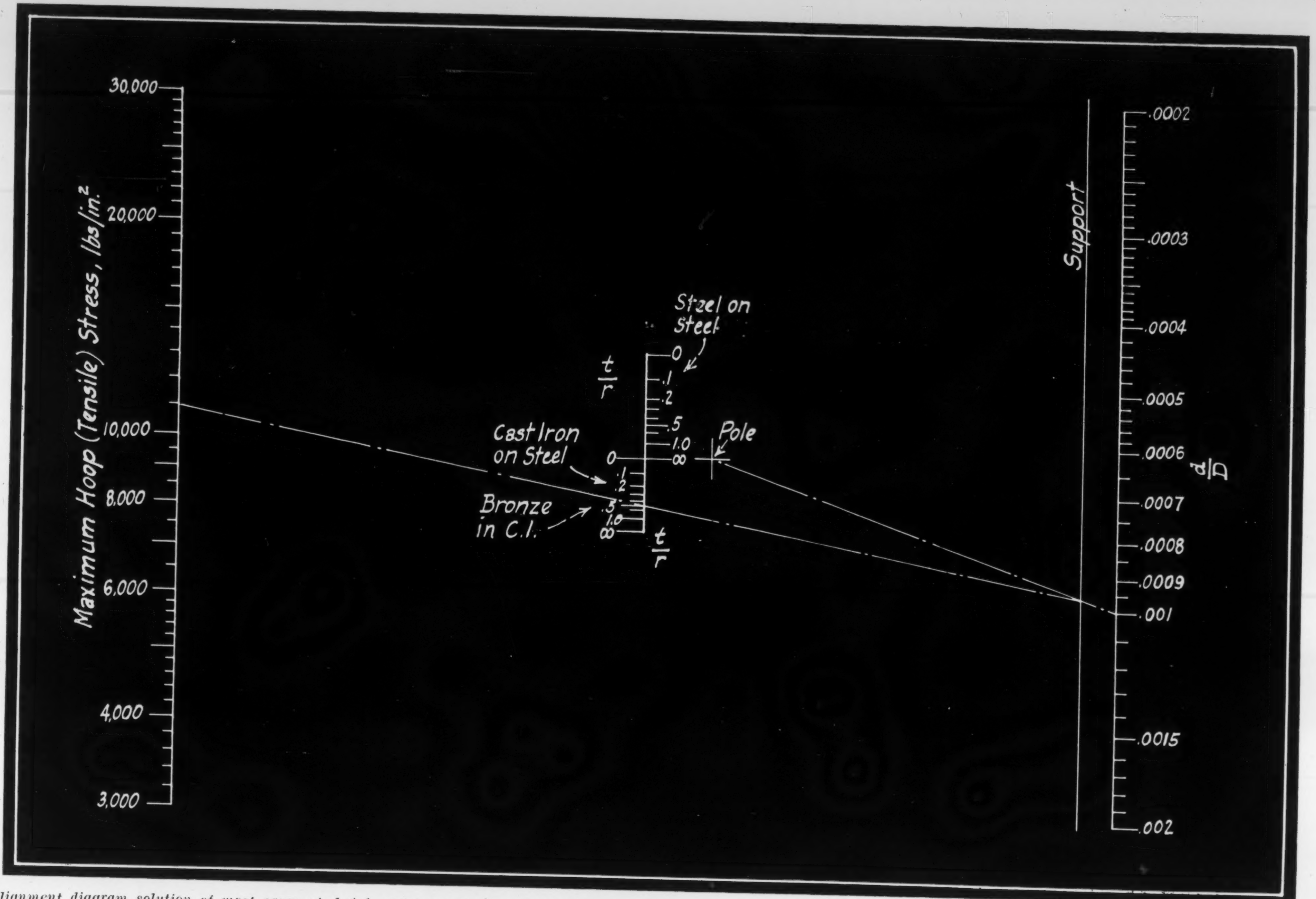
In the position shown, the crank and slide are at the bottom of their stroke and the crank is turning in a clockwise direction. Since surface *E* of the crankpin is concentric with the crankshaft, the slide will remain stationary while this surface is in contact with bottom *F* of the elongated slot. However, as soon as surface *E* leaves bottom *F*, side *G*, coming in contact with the top of the elongated slot will force the slide upward to the upper end of its stroke. At this point, surface *E* engages the top of the slot, and as at the bottom of the stroke, the slide is dwelled. Following this dwell, side *G* forces the slide downward to the position shown, thus completing the cycle.



Modification of Scotch yoke is designed to give a long dwell to slide at both ends of stroke

In spite of the relatively sharp corners on the crankpin, this design is very efficient and the wear at these points and in the slot is so slight it can be ignored. Its greatest advantages however are its simplicity and inexpensive construction which are important factors not to be overlooked.

—J. E. FENNO,
Belleville, N. J.



Alignment diagram solution of most cases of shrink and force fits, described on the preceding page, is based on the Lame thick cylinder theory for the special cases where the inner cylinder becomes a solid shaft

MEN OF MACHINES

AN ENGINEERING background again contributes toward high attainment in the patent profession. C. E. Tullar, University of Minnesota graduate in engineering, has become vice president in charge of the General Electric patent department.

After leaving college he was for a time engaged as an operating engineer with St. Paul Gas Light Co. and Fairbanks-Morse Co. In 1904 Mr. Tullar entered government service as an electrical engineer and draftsman. A year later he went into the U. S. patent office as an examiner.

Advancement through the various grades led to an appointment in 1917 as principal examiner in charge of one of the electrical divisions. In General Electric's patent division, with which he became affiliated in 1919, he rose to manager in 1928.

C. E. TULLAR

• • •

WALTER H. BURR

MECHANICAL and electrical departments of Lukens Steel Co. are under the supervision of a man who needs no introduction to members of his profession. He is Walter H. Burr, newly-elected president of the Association of Iron & Steel Electrical Engineers.

After his graduation from Rose Polytechnic institute in electrical engineering in 1905 he went with Westinghouse. There he remained in various capacities until 1917 when he went with Allan Wood Steel Co. Joining Lukens in 1921, Mr. Burr became superintendent of mechanical and electrical departments in 1932.

In the A. I. S. E. E. organization of which he has been a member for 17 years, he has served as chairman of the developments committee for the past seven years, indicative of an active part in association affairs.

• • •

NATIONAL Machine Tool Builders association has as its new president Charles J. Stilwell, vice president and director of Warner & Swasey Co. He brings to his new post a wealth of experience in the industry.

Moving to Ohio from Freehold, N. J., where he was born Sept. 13, 1886, Mr. Stilwell attended High school in Cleveland and later Denison university. In 1910, immediately after his graduation, he went to the Warner & Swasey Co., taking the apprenticeship course.

During 1913 and 1914 he served as the company's European manager, subsequently becoming assistant to the president. In 1918 he was made foreign sales manager and in 1922 general sales manager. A directorship and vice presidency was accorded

C. J. STILWELL

him in 1930. Mr. Stilwell is a member of the committee of Russian-American trade of the National Association of Manufacturers, and the National Advisory Committee on Foreign Service of the National Foreign Trade Council.

* * *

William Spraragen, who for the past 15 years has held the position of secretary of the division of engineering and industrial research of the National Research council, has become president of the newly organized Spraragen Engineering Corp. He continues as secretary of the American Bureau of Welding.

* * *

Dr. Frederic M. Becket, president of Union Carbide and Carbon Research Laboratories Inc., has been elected to honorary membership in the Electrochemical society of which he was president in 1925.

* * *

Ambrose Swasey, noted inventor and chairman of the board of Warner & Swasey Co., was honored recently at a dinner celebrating the twentieth anniversary of the Engineering Foundation. He was instrumental in establishing this organization.

* * *

J. R. Townsend, general development laboratory, Bell Telephone Laboratories Inc., has been elected chairman of committee B-6 on die cast metals and alloys of the American Society for Testing Materials.

* * *

Maurice Thorne has joined the engineering staff of Olds Motor Works in the capacity of project engineer, a newly created position. He formerly was chief experimental engineer of Pierce Arrow Motor Car Co.

* * *

Dr. Erwin R. Stoekle, chief engineer and vice president of the Globe-Union Mfg. Co., Milwaukee, recently was elected president of the Engineers Society of Milwaukee. **Bruno V. E. Nordberg**, executive engineer, Nordberg Mfg. Co., is vice president.

* * *

Charles H. Herty Jr. recently has been appointed a research engineer in the development and research department of Bethlehem Steel Co.

* * *

Major E. E. Aldrin, head of the aviation department of Standard Oil Co. of New Jersey, who was awarded the decoration of the Commendatore of the Crown of Italy on his recent trip abroad, has been elected a fellow of the Institute of the Aeronautical Sciences.

* * *

Dr. Vsevolod N. Krivobok, a member of the research staff of the bureau of metallurgical research, Carnegie Institute of Technology, recently joined the research staff of Allegheny Steel Co.

* * *

Alfred V. Verville, designer and former manufacturer, recently was appointed chief of the manufacturing inspection service of the bureau of air commerce.

* * *

Dr. Leo Hendrik Baekeland, president of Bakelite Corp. and internationally known research chemist, is the recipient of the degree of Doctor Honoris Causa of the University Libre de Bruxelles. The honor was announced at the recent opening of the centenary celebration of the Belgian university. A photograph and biographical sketch of Dr. Baekeland was presented in the May, 1932, issue of Machine Design.

* * *

J. A. Ehlinger has been placed in charge of the engineering department of Ryan, Scully & Co. which recently was purchased by R-S Products Corp., Philadelphia.

* * *

Frank D. Peltier, formerly affiliated with the engineering division of Servel Inc., Evansville Ind., recently was named assistant to **F. P. Negrbas**, senior vice president. He has been with the company since 1925, during most of this time having been engaged in engineering and research with the title of assistant chief engineer.

* * *

Dr. V. J. Andrews now is affiliated with the National Union Radio Corp. of New York. He will work with radio set manufacturers on scientific problems connected with receiver design.

* * *

Claude A. Steadman recently joined the Pioneer Engineering & Mfg. Co., Detroit. He formerly was associated with various motor companies, later with Taft Pierce Mfg. Co. and for the last five years with Wright Aeronautical Corp., Patterson, N. J. as chief tool designer.

Obituaries

JOHN F. KELLY, 53, managing director of the Association of Iron and Steel Electrical Engineers and editor of the *Iron and Steel Engineer* for the past seventeen years, died at his home in Pittsburgh Nov. 16. His reputation was nation-wide in iron, steel and electrical circles. Prior to his trade paper associations, he had been assistant superintendent in the electrical department of National Tube Company's McKeesport, Pa., works.

* * *

Charles B. Jacobs, inventor and metallurgist, died recently at Waterbury, Conn. He was associated for some time with the American Brass Co. and received the John Scott medal in 1914. For many years he maintained a laboratory in New York.

* * *

R. Y. Ferner died in New York recently. Born in Chicago fifty-eight years ago, he graduated from the University of Minnesota, became a physicist at the bureau of standards and at one time was a computer with the naval observatory. Fifteen years ago he founded the R. Y. Ferner Co., Washington.

* * *

Prof. James G. Gray, inventor of gyroscopic aerial and marine appliances, died recently at Glasgow, Scotland. He had been since 1920 professor of applied physics at Glasgow university.

* * *

George W. Drake, chief machine designer with Warner & Swasey Co., Cleveland, died recently at the age of 73. He became affiliated with the company in 1888 as a draftsman. He was the inventor of a number of machine mechanisms for which he was given patents and was an expert mathematician.

ASSETS TO A BOOKCASE

Machinery's Handbook

Edited by Erik Oberg and Franklin D. Jones; published by Industrial Press, New York; available through MACHINE DESIGN *for $6.00 plus 15 cents postage.*

The ninth edition of this well-known and widely accepted handbook recently was brought out to include new and revised standards and other information of importance in design and construction of machinery. Major revisions embody new strength of materials data; load capacities of ball and roller bearings; recent developments in plain bearing design; new tables and information on designing different classes of gearing, including spiral, bevel and hypoid gears; enlargement of small pinions to avoid undercut teeth, and a great deal of additional technical data representing recent progress in engineering and manufacturing practice.

Since 1930 there have been 367 additions and revisions. This new edition alone contains 172 revisions and improvements ranging from complete new sections to small but important changes. The handbook is divided into 126 main subjects with a complete index. There also is a special "thumb index" for locating any one of the fourteen main sections of the book.

□ □ □

Die Castings

By Herbert L. Chase; published by John Wiley & Sons Inc., New York; available through MACHINE DESIGN *for $3.50 plus 15 cents postage.*

Because the author of this comprehensive volume on die castings was in touch with the foremost authorities in the industry in the preparation of data, he contributes a composite of information that is a genuine contribution to engineering literature. Methods employed in the production of die castings are presented briefly but the bulk of the text deals with the product itself, including composition, uses and design.

The book contains that type of explanation which will aid designers who are considering die castings as well as those who are already using them. A glance at some of the subjects that are covered reveals its wide scope. For instance it demonstrates the technical possibilities of die castings; sets forth characteristics of various suitable alloys; and instructs the reader in the design of die castings.

In conclusion Mr. Chase discusses finishes, a division of the book that is of particular interest. He outlines the types of finishes available and includes useful particulars on the preparation of castings of the die cast type for finishing and on methods used in the finishing processes.

□ □ □

Principles of Mechanism

By C. E. Pearce; published by John Wiley & Sons Inc., New York; available through MACHINE DESIGN *for $3.50 plus 15 cents postage.*

Although intended as a text book for technical courses, the material prepared by the author, professor of machine design at Kansas State college, will serve to refresh the memories of many engineers in practice. In numerous cases he uses photographs of commercial parts and mechanisms to supplement his sketches of the subject under consideration. His co-ordinated development of chapters covering transmission of power have been enhanced with various views of installations which help the reader visualize the practical aspects of the problems discussed.

In compiling the text matter he made it a point to see that the material is confined largely to the more common forms of the five types of mechanisms and of wheel trains. Discussion in each chapter suggests the advantages, possibilities and limitations of these mechanisms.

□ □ □

Engineering Drafting

By William G. Smith; published by McGraw-Hill Book Co. Inc., New York; available through MACHINE DESIGN *for $2.25 plus 15 cents postage.*

This is another book in the category of a classroom tool. Practicing engineers, however, may find it useful for reference and as a guide for those who are juniors in their departments. Some of the interesting objectives of the author, who is professor of engineering drawing at Northwestern university, may be classified as follows:

Figures for most exercises are drawn out of scale intentionally, making it necessary to rely on the dimensions rather than on the dividers. Many of the less important dimensions are omitted to compel the student to depend on his own feeling for design and sense of proportion for outline curves, fillet radii, sizes of bosses and other minor items.

NOTEWORTHY PATENTS

TO CREATE vacuum at the proper interval in the cycle of operation for holding the film flat over the photographic exposure area during the exposure interval an interesting mechanism has been designed for a camera recently patented by William A. Black. Number of the patent is 1,974,842 and Fairchild Aerial Camera Corp. is assignee. Devices also are embodied in this unit to correlate the functions of the various mechanisms in sequence.

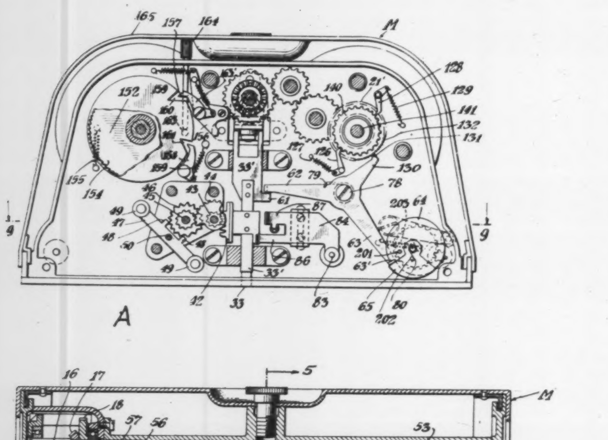


Fig. 1—Vacuum created at the proper interval holds film flat over exposure area in camera

Plunger 33′ (*Fig.* 1 *A*) carries a rack 42 which operates a pallet retard providing uniform movement of plunger 33 as it is moved up and down. The purpose of this mechanism is to provide proper sequence of operation of the vacuum system and the shutter trip and for a definite time interval between these operations. This is brought about by meshing of rack 42 with a small gear 43 carrying a larger gear 44 that engages smaller gear 45 connected to pallet wheel 46 which is alternately engaged by forks 48 of pallet bar 47 pivoted at 50. Suitable weights 49 are attached to the end of the pallet bar.

As rack 42 and bar 33′ move upwardly on the release of a solenoid (not shown) from bar 33, a forked plate carried thereby moves upward to allow spring 53 (*Fig.* 1 *B*) to pull a bar 52 to the left. As this occurs the forks of the plate push upwardly on a pivoted catch 56, removing it from the end of bar 52 against the action of spring 57. This movement of the bar to the left causes a counterclockwise movement of a bell-crank 58 and consequent upward movement of piston 59.

The suction device consists of piston 59 fitting in cylinder 72 which is open at its upper extremity and provided in its lower wall 73 with a number of apertures 74. Continuous with this lower wall of the cylinder is a plate in the form of a grid. It is designed with grooves for distributing the suction effect created in the cylinder throughout the entire face of the plate. Communication between the cylinder and cross grids is obtained through apertures 74.

Upward movement of the bar which occurs after the shutter has been tripped, forces an arm 62 of a device pivoted at 78 (*Fig.* 1 *A*) upwardly against action of spring 79 by means of engagement of lug 61 with arm 62. The effect of this is to pull arm 63 in a clockwise direction against action of spring 203, so as to release lug 63′ out of engagement with the corresponding recess in a measuring roll 64. As long as lug 63′ is in engagement with the notch in the measuring roll it is impossible to advance the film.

BY PRODUCING an electrical charge on the surface of a feed drum by friction, W. J. Hawkins has developed an unusual tobacco feeding arrangement for American Machine & Foundry Co., New York. The invention recently was granted patent No. 1,977,991. The friction device, *Fig.* 2, consists of a rubbing element 8 made of leather, vulcanized rubber or similar substance different from the non-conducting material of the feed drum 4. The element is coated with an amalgam to increase its charge-producing effect on the rotating surface of the drum.

Mounted in frame 9, the friction element extends along the entire width of the feed drum

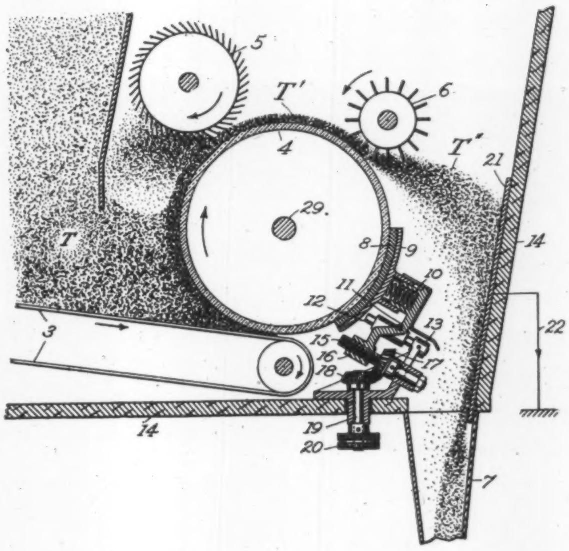


Fig. 2—Friction is employed to charge a drum with static electricity for feeding tobacco

and is pressed against it by a row of coil springs 10 carried in sockets of an adjustable bar 11. An endless belt 3 continuously advances the tobacco *T* in the feed magazine and a carded "refuser" drum 5 trims down the layer on the feed drum to the required thickness. Also provided is a picker roller 6, the pins of which dig into the tobacco layer and remove it from the receiving drum. Chute 7 delivers the supply to the cigarette wrapper strip as it is fed through a cigarette machine.

INSTALLATIONS employing fractional horsepower motors, such as refrigeration units, domestic water pumps, oil burners, etc., are considered as a field for a newly patented friction drive device. The inventor is Arthur P. Lewis and Firestone Tire & Rubber Co., assignee. Mounted on the end of shaft 18, *Fig.* 3, is a disk or flywheel 19 that is provided with a flange 20 to the inner perimeter of which is secured retainer 21 for a frictional element 22. In mounting the strip in the retainer, the former is bent longitudinally to ring shape with the result that the outer peripheral portion is under tension and the inner section is placed under compression. This causes the strip to assume a transversely arcuate shape that is concave on the outer periphery.

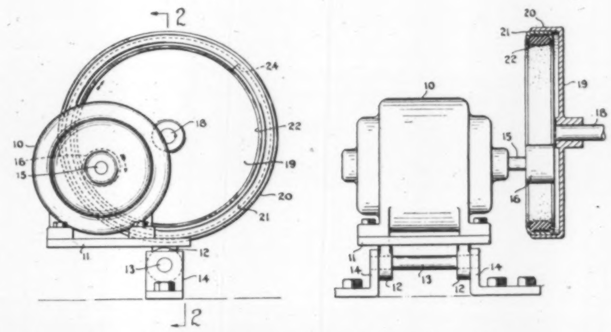


Fig. 3—Pressure between driving and driven members of friction drive is proportional to load

Driving pulley 16 of motor 10 bears against the friction strip 22, proper driving being maintained by gravity. Pressure of the pulley forces element 22 more firmly into retainer 21 and thus augments the normal compression of the strip in resisting any relative movement between it and the retainer.

Motor 10 is driven in the direction indicated by the arrows. Relative positions of pulley 16 and pivot 13 are such that added load on the driven member results in additional pressure of the pulley against the friction member. Thus the pressure automatically becomes proportional to the load. The coefficient of friction between the materials used for the pulley and strip is extremely high, approaching unity. The patent is designated No. 1,979,561.

A VIBRATION damper recently patented by W. W. Harris for Continental Motors Corp. provides improved means for yieldingly connecting the inertia member of the damper to a crankshaft or damper hub. An important feature is the forming of members 13 and 14 with annular undulations indicated at *B* and *C*, *Fig.* 4. Annular peaks of one of the members are aligned longitudinally with the valleys of the other plate member and the rubber annulus 17 is molded to fill the space between.

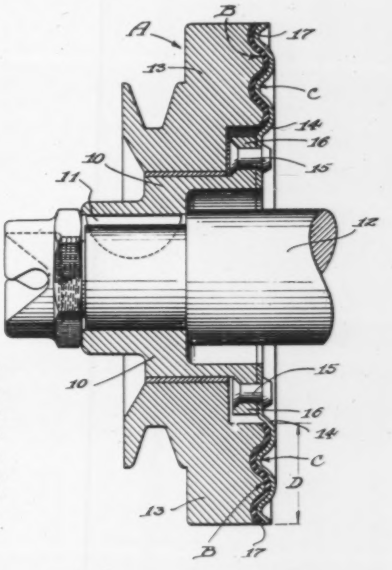


Fig. 4—This vibration damper is designed to provide increased area of vulcanized rubber surface for a given available radial distance

By designing the mechanism with undulations instead of flat parallel faces the inventor has materially increased the area of vulcanized surface for a given radial distance *D*. If desired, the patent sets forth, the peaks and valleys may be formed by plane surfaces although the curved form illustrated is preferred. Another advantage resides in subjecting the yielding material such as rubber to shearing action as distinguished from compression. The rubber, Mr. Harris declares, will not tend to deteriorate as in the case of rubber under compression.

Number of the patent is 1,978,199.

BECAUSE of the increased attention being given to ways and means of preventing the formation of dust in operation of machinery, particularly pertinent is the design of a dustless rock drill which has been granted a patent. The designer is Fred M. Slater who has assigned his patent, No. 1,978,964, to Ingersoll-Rand Co. One object of the invention is the prevention of pressure fluid leakage through the anvil block 31 and along the water tube into the drill steel 27.

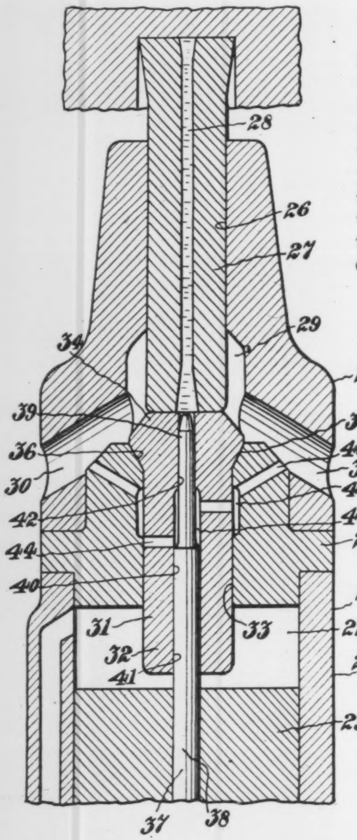


Fig. 5—Leakage of air pressure through the anvil block and along the water tube into the drill steel is prevented in this rock drill. That air which may find its way into bore 40 is conducted to the atmosphere

A portion of the bore 26 is enlarged as at 29, *Fig.* 5, this enlarged portion communicating with the atmosphere through passages 30 in the front head. Thereby is provided an escape for such water and entrained cuttings that may flow downwardly along the drill steel into the front head. The drill is the air-actuated stopper type comprising a cylinder 21 with a piston chamber 22 to accommodate a reciprocatory hammer piston 23.

Water conveyed by passage 28 to the drill hole is introduced into the passage by water tube 37 extending through the percussive element of the mechanism. During operation of the device such air as may find its way from the front of the piston chamber 22 into bore 40 passes through passages 44, 45, 46 and 30 to the atmosphere instead of entering the drill steel to comingle with the water flowing through it and causing dust in dry form to be expelled.

Builder and User Should Co-operate for Safety

A MACHINE designed with safe and complete control built-in, is obviously worth more than a machine with unsafe or incomplete control," according to W. S. Gundeck, manager, Co-operative Department, Studebaker Corp., who spoke at the recent Safety Congress of American Safety council. Mr. Gundeck stated that "The first machine may be placed in production without loss of time while the second will require much time and work to equip it with safety features before it can be placed in production.

"The cost element of safeguarding a machine at its source is not of great consequence. The modern machine tool is becoming more complicated daily as the demand increases for automatic tools for performing multiple operations. This type of machine requires considerable study as to control schemes and safety devices.

Safety Can Be Built In

"It is rather generally conceded by most machine manufacturers that safety devices in most cases can be built into the machine at the source without sacrificing the efficiency of the machine. As a matter of fact, some contend that in most cases the efficiency of a machine can be increased with the inclusion of safety devices as an integral part of the machine and as a unit.

"The responsibility for satisfactory development of safety by engineering revision must be shared between the machine manufacturer and the machine user. I am convinced that a closer relationship between the manufacturer, purchaser and designer would result in and would bring about a more sympathetic understanding of the problems involved.

"Many purchasers say nothing about safety features, probably because they assume that the maker of a high-grade machine has attended to them. Occasionally a purchaser will have special safety requirements and usually wants them built into the machine. However, if the purchaser does not pass the information he has gained from the actual use of the machines to the manufacturer, he is lacking in his appreciation of the problems that the manufacturer is facing in designing accident-proof machines.

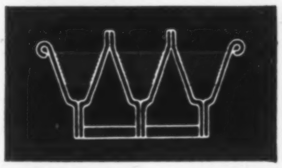
"The machine builder should build safety devices that might reasonably be required because he is best able to design them so that they will not interfere with the efficient operation of the machine, and so that they will harmonize with the design as regards the appearance of the complete machine."

ANNOUNCING!

The new
DURO-BRACE TEXSTEEL SHEAVES

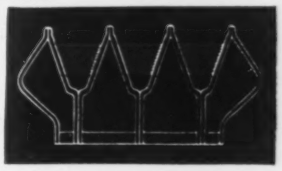
The Allis-Chalmers Manufacturing Company, originators of multiple V belt drives, now offers a new development in sheaves which will withstand the severest duty. • Bending of the outside plate is practically impossible with the new Duro-Brace Sheaves, for in the new design this vulnerable area is braced by a reinforcing convex steel plate, which increases its strength to so great a degree as to eliminate distortion, even under extreme overloads; thus giving a true running drive always. • Duro-Brace Texsteel Drives are 98.9% efficient . . . Require no belt dressing or lubrication . . . Are unaffected by moisture or dust . . . Are Vibrationless, Slipless, Silent, Light and Clean. • Mail us a card asking for Bulletin No. 2188 which sets forth the advantages which Duro-Brace Texsteel Drives offer you in all matters of power transmission, whether they are simple or complex.

Former Design: *cross-section showing unsupported outside plate.*

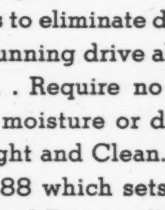


★ ★ ★

New Duro-Brace Design: *cross-section showing outside plate braced by a convex reinforcing steel plate.*



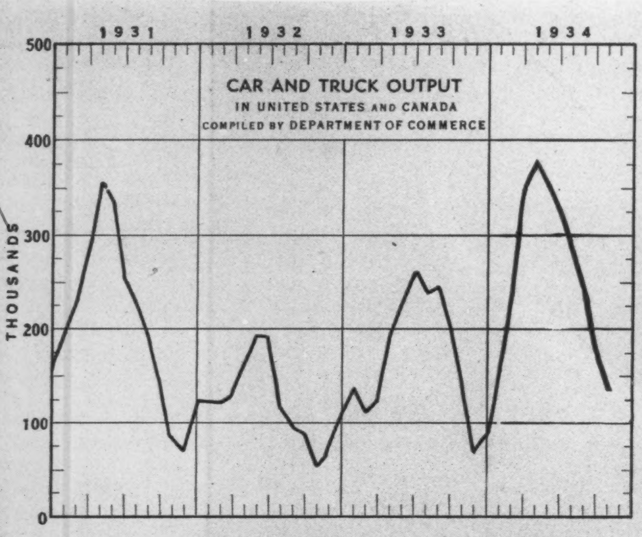
TEXROPE DRIVES



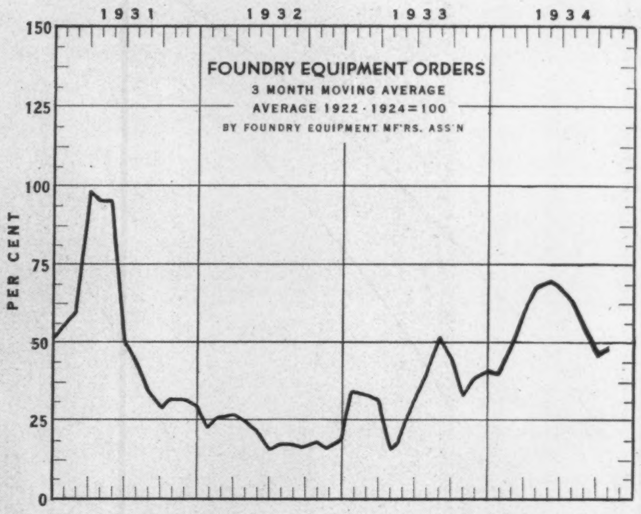
ORIGINATED BY ALLIS-CHALMERS

ALLIS-CHALMERS MANUFACTURING COMPANY • MILWAUKEE, WISCONSIN

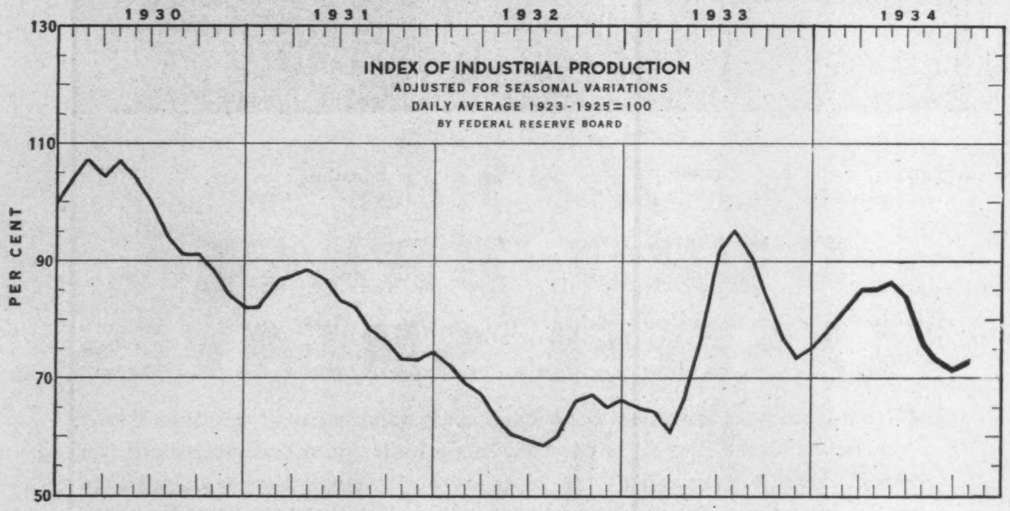
How Is Business?



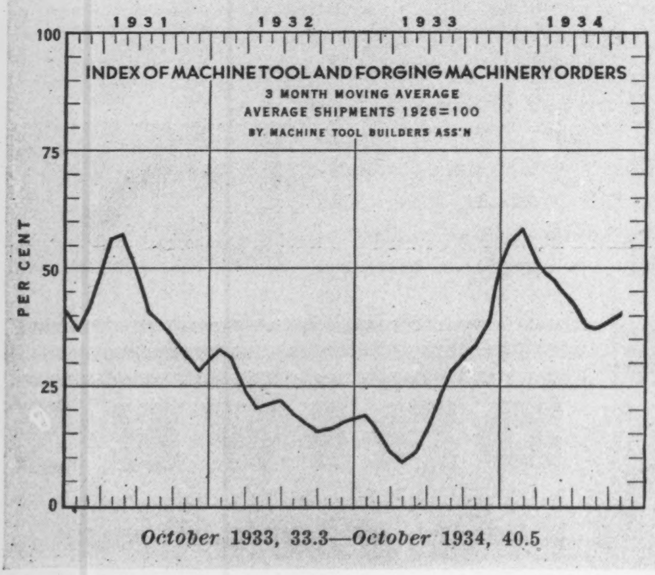
October 1933, 138,365—*October* 1934, 136,268



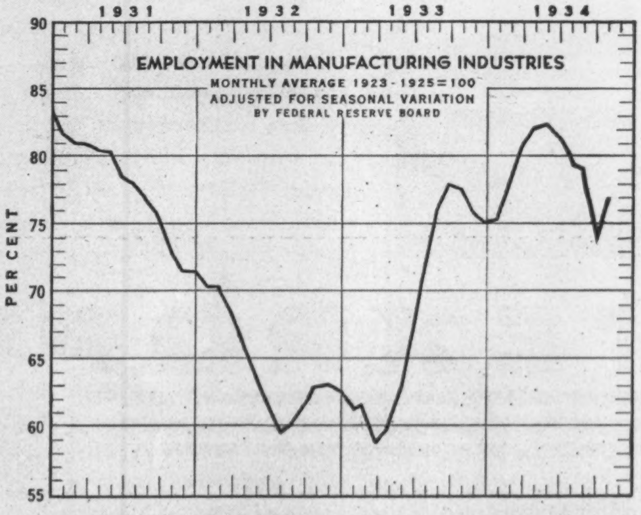
October 1933, 44.6—*October* 1934, 48.3



October 1933, 76—*October* 1934, 73



October 1933, 33.3—*October* 1934, 40.5



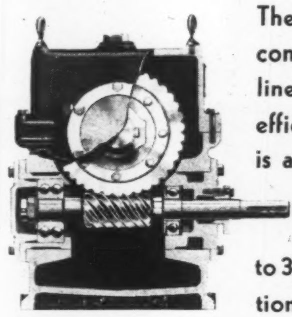
October 1933, 77.8—*October* 1934, 77.0

Speed Reducers IXL *For Every Need*

THE MARK OF QUALITY

THESE TWO LINES ARE TYPICAL

HyGrade



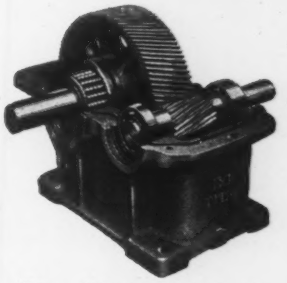
Cutaway view of Type HGS HyGrade worm reducer

The IXL HyGrade worm reducers constitute a complete and versatile line of anti-friction bearing, high efficiency, heavy duty units. There is a complete series of single and double reduction units available in ratios from 4 to 1 up to 3000 to 1 and capacities from fractional h.p. up to 150 h.p. The gears provided in these units are the result of many years of development work and research. They have a special involute tooth form, so cut that the line of contact is as near perfect as worm gearing can be made. The result is minimum sliding action and maximum rolling action and a very efficient smooth running gear set.

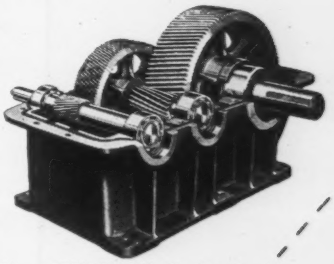
Type HGV HyGrade vertical worm gear speed reducer

TITAN

The IXL TITAN line of anti-friction bearing speed reducers comprises a complete series of single and double reduction reducers with helical or herringbone gears, as desired, in sizes from ½ h.p. to 300 h.p. and in standard ratios from 2.87 to 1 to 96.2 to 1. The helical gear, in addition to its ease of alignment and its ease of adaptation to heat treatment also has inherent quiet-running properties which are retained throughout the life of the gear. Herringbone gears are optional in these units, but helical are recommended because of greater strength and longer life.



Type SX single helical reducer



Type DX double helical reducer

Foote Bros.
GEAR AND MACHINE CO.
5303 SO. WESTERN BLVD.
CHICAGO, ILL.

MEMBER OF AGMA

You Can Depend on IXL *Products*

Back of every IXL product is an organization with a reputation. This company operates the most modern and complete gear cutting plant in the country. Seventy-five years of successful manufacturing experience guides the policies of this plant. An outstanding engineering department is in charge of research and design and sales engineers are available in every important city to cooperate with you in solving any problem involving gearing or power transmission. Use the coupon to request our handbook on "Gear Problems."

Speed Reducers, Powered Gears—Flexible Couplings — Friction Clutches—Gears of all Kinds

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☐ Please send me, without obligation, copy of the 664-page designing engineer's text book, "Gear Problems."

☐ Please send copy of the A.G.M.A. Recommended Practice for Rating of Speed Reducers.

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Address..............................

TOPICS

DISCUSSING advantages of flame cut surfaces for welding, C. W. Obert in a paper presented before the recent Pittsburgh convention of the International Acetylene association described the effect of gas cutting. The oxidation on a gas cut surface in ordinary low carbon steel has been shown, he said, to be a surface condition only and the heating of the cut surface to be limited, with usual cutting rates, to a slight penetration. Not enough heat from the cutting flame is retained to show an appreciable red color. No change from the original structure is indicated other than a slight increase in carbon in an almost microscopical surface thickness. No objectional physical effects have been traced by tests to the changes that occur in the cut surface.

In another paper T. R. Moxley, Wheeling Steel Corp., declared that as opportunity permits, fabrication by welding is replacing castings in his shop. "Probably the greatest advantage which welding gives us," said he, "is the possibility of improving the design of machine parts. Patterns are eliminated; consequently when a change is indicated the cost of pattern alteration does not hold us back."

* * *

Sees China As Best Overseas Market

China, as seen by Commercial Attache Julean Arnold, is likely to become the best overseas market for American machinery and allied lines. He points out that China with its large and industrious population now is in the process of emerging from the domestic handicraft stage into mechanized industry.

* * *

Safety in Air Travel Improved

Looking at the record of American-operated passenger air lines it is found that they flew 796,950 miles per accident in the first six months of 1934 as against 538,794 miles for the same period in 1933. In other words the safety in air travel has been improved, all of which speaks well for aeronautical engineering. There were but twenty-seven accidents in 21,517,658 miles of flying during the first six months of the year, compared with forty-eight accidents for the same period last year. Causes of the twenty-seven accidents are listed as follows: personnel errors, 52.04 per cent; power plant failures, 11.85 per cent; airplane failures, 18.51 per cent; weather, 14.62 per cent; airport and terrain, 0.93 per cent, and other causes 1.85 per cent.

* * *

Auto Is Largest User of Steel

Examination of the records of the steel industry shows that last year the most important consumers of its output were the automobile, container, building and railroad equipment industries in the order named. This group used fifty-three per cent of all the finished steel produced, the automobile alone taking twenty-one per cent. The picture is changed considerably from that of the market a few years ago when the railroad was the largest buyer.

* * *

Oil Burner Makes Marked Progress

Several years ago the domestic oil burner's possibilities still were being weighed; today its acceptance is a fact. The field is even more extensive than was anticipated, as indicated by a recent large installation. A unique multi-unit central heating plant consisting of 120 General Electric domestic oil furnaces was installed during the past summer at Mount Holyoke college. They are arranged to operate automatically in a single battery. The new central plant comprises the major portion of a total of 172 furnaces which provide complete new heating equipment for the college.

* * *

Standard Ready for Discussion

A proposed American standard for pressure and vacuum gages (gage sizes, mounting dimensions, size and type of connections of gages and cocks, indicator hands and stop pins) recently was completed by subcommittee No. 3 of the sec-

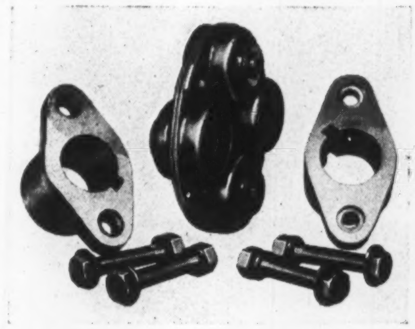
ADVERTISEMENT—*Each item on this page is a paid advertisement*

POWER TRANSMISSION NEWS

Engineer or not, the person with a mechanical bent enjoys seeing a unit which has been developed and refined to the point where maximum efficiency is obtained with an utterly simple assembly.

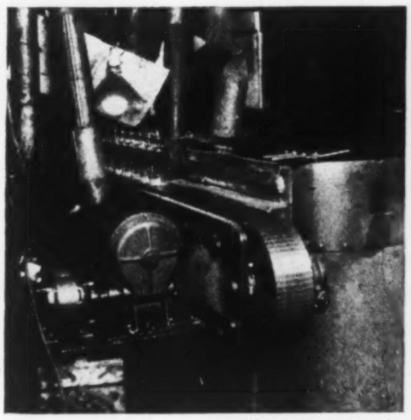
These are the chief characteristics of the Morflex Coupling, and are the reasons for its widespread use in many places.

Originally, it was developed as a universal joint to compensate for angular or parallel misalignment, and its adoption in many fields was rapid. It is now widely used in both automotive and marine service.



This illustration shows the simple assembly and the few parts which constitute this flexible coupling. The two forged steel hub members are mounted on the shafts to be connected; between these is carried the floating center, to which each hub is separately connected through a pair of resilient rubber trunnion blocks, which are set 90° apart under pressure into a 2-piece riveted housing of pressed steel. The blocks are molded over, and permanently fastened to steel cores or bushings. The outer section on the rubber block is a fabric ring, which holds it securely in the steel center. The shape of the rubber was carefully designed to give uniform stress and deflection throughout—an important feature which adds greatly to the life of the coupling.

The extreme flexibility of the unit is due to the resilient, non cold-flow rubber blocks—especially developed for this service. More than in any other coupling the design provides for misalignment and used in pairs Morflex is a perfect universal joint for shafts not in line.

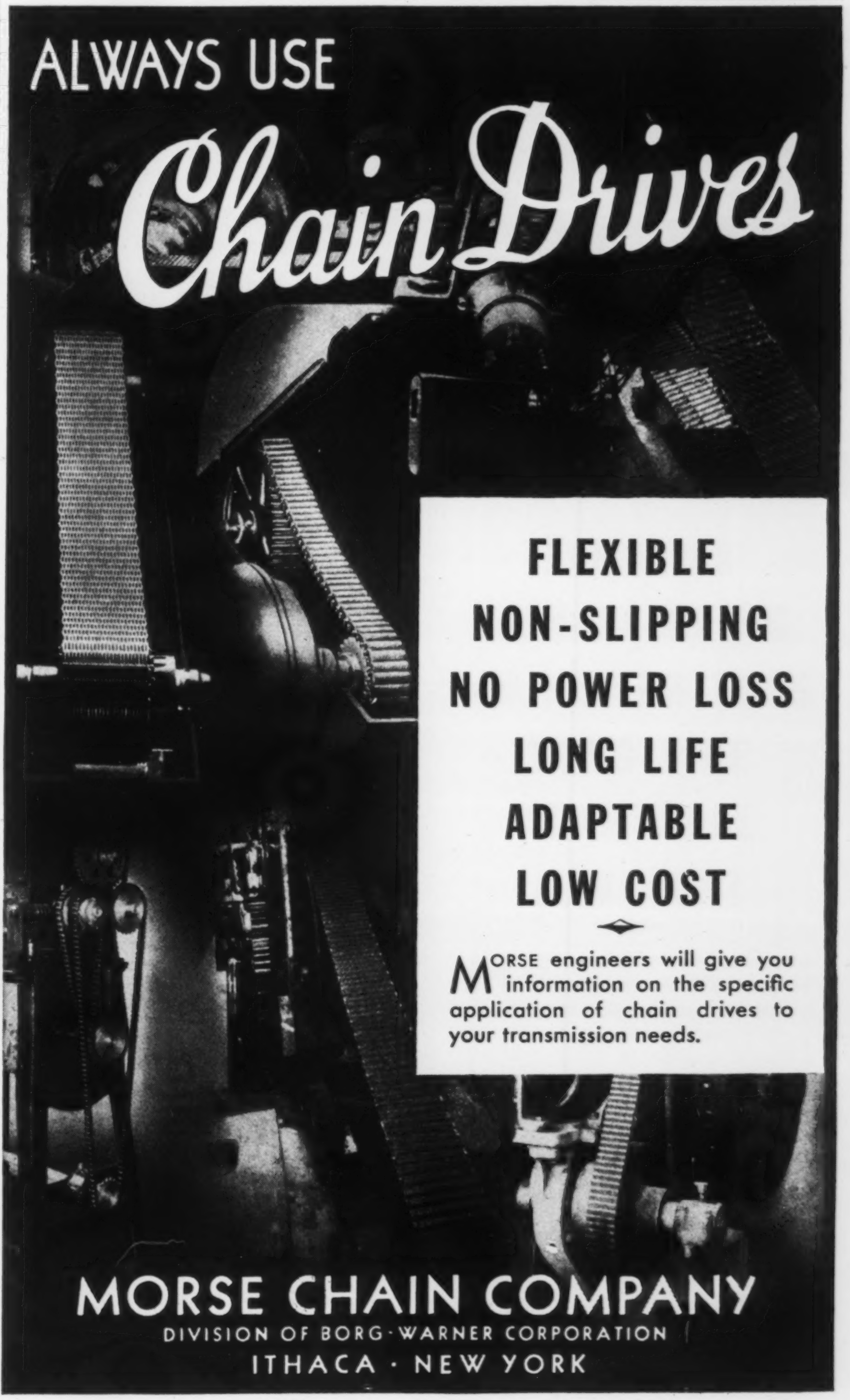


The ingenuity which characterizes the products of the glass industry has been applied to a production problem in the plant of the Obear-Nester Glass Co., East St. Louis, Illinois.

The problem was that of production-handling of hot bottles. Company engineers solved it by installing a Morse Silent Chain, connected to the drive shaft and an idler shaft—and it provides a perfect hot-bottle conveyor.

This unusual but entirely practical application of the Morse Silent Chain Drive employs a chain with ½" pitch and 4½" wide, traveling at a speed of 6 feet per minute.

Continuous operation for twenty years—that's the record of one Morse Chain. Commenting on Morse Chains, this user says, "This chain is hooked up to a five-horsepower motor on a line shaft running thirty-eight machines. This chain has been in continuous operation for twenty years and the way it looks today, there is a possible chance of its running twenty more years. We use this type of drive exclusively in all our plants, scattered over the country. We believe this is the best and most efficient drive. We put a few drops of oil on these chains once a month and take up on the motor once a year, with no interruption or loss of time."



ALWAYS USE

Chain Drives

FLEXIBLE
NON-SLIPPING
NO POWER LOSS
LONG LIFE
ADAPTABLE
LOW COST

◆

MORSE engineers will give you information on the specific application of chain drives to your transmission needs.

MORSE CHAIN COMPANY
DIVISION OF BORG-WARNER CORPORATION
ITHACA · NEW YORK

tional committee. This standard now is in tentative form for discussion, and criticism and comment will be welcomed. All communications should be addressed to C. B. LePage, American Society of Mechanical Engineers, 29 West Thirty-ninth street, New York. The sectional committee was organized in 1930 with the A. S. M. E. as sole sponsor under the procedure of the American Standards association.

* * *

What Has Kettering in Mind?

Much interest has been aroused by a statement of Charles F. Kettering in the foreword of a booklet entitled *"Research—An Eye to the Future,"* published by General Motors Research division. In it he says: "It is not what we know that is so important—it is what we do not know. Most of what we know can be found in libraries, in the minds of the people and in processes as they exist today. Each year we discover new things which a short time ago we did not even know existed. I cannot help but feel that in a very short time we are going to break loose another great piece of basic information which will keep us industrially busy for a great many years to come." Mr. Kettering does not reveal the nature of the basic information he anticipates. The booklet itself is devoted to the value of research in the laboratory, on the proving ground and by questioning car owners.

* * *

England's Unique Patent Record

Patent news coming from England reveals that during the six months ended June 30 applications for new patents numbered 19,403. Lord Asquith gave out this information when he recently opened the exhibition of inventions at the Central Hall, Westminster, London. He further declared "it is curious to note that during the year just passed there has been in the United States a decrease in application of nearly 3000 while in Great Britain there has been an increase of 1000 in six months." Lord Asquith set forth that it does not always follow that people in certain occupations use their knowledge of those occupations to further their inventive genius.

* * *

Magnet Weighs Forty Tons

Periodically news of interesting technical developments comes out of Russia. One of the latest accomplishments in that country is the assembly of one of the world's largest magnets. It weighs forty tons and recently was completed at the Electrosilia Works, Leningrad, as part of an atom-bombardment apparatus to be installed at the Radium Institute in that city. Made of chemically pure iron containing only a fraction of one per cent carbon, the magnet's action is expected to attain an equivalent of 6,000,000 volts.

* * *

Engineering Scores High Again

A recent survey made among freshmen at Lafayette university revealed that of 207 interviewed fifty-one have decided to follow engineering, twenty-four law, seventeen medicine, twenty-eight plan to go into business, eight want to be dentists and eight journalists.

* * *

Valve and Inner Tube Are Now One

A new valve stem with a copper base made an integral part of the inner tube by vulcanizing has created widespread interest. This feature makes the device permanently air-tight at the base. It is said to be capable of withstanding strain far in excess of that caused by today's driving speeds.

* * *

Stimulant for Inventive Genius

To encourage inventive genius a special exhibition of new inventions open to all nations has been made a permanent feature of the Leipzig Trade Fair. Special attention will be given to all devices which have not been exploited industrially. The displays are to be arranged so that every inventive idea of merit will be demonstrated to the best possible advantage to visitors from the seventy-two nations that send representatives to the fair.

* * *

Novel Method of Testing Stress

Wires buried in the concrete of the renowned Dnieprostroy dam in Soviet Russia are being employed to test stress and load. As these two factors change the tension in the huge structure the wires change their pitch, providing the basis of mathematical calculations that indicate the strain the dam is undergoing. Seven years of experimenting carried on in Germany is behind what is known as teletensometry.

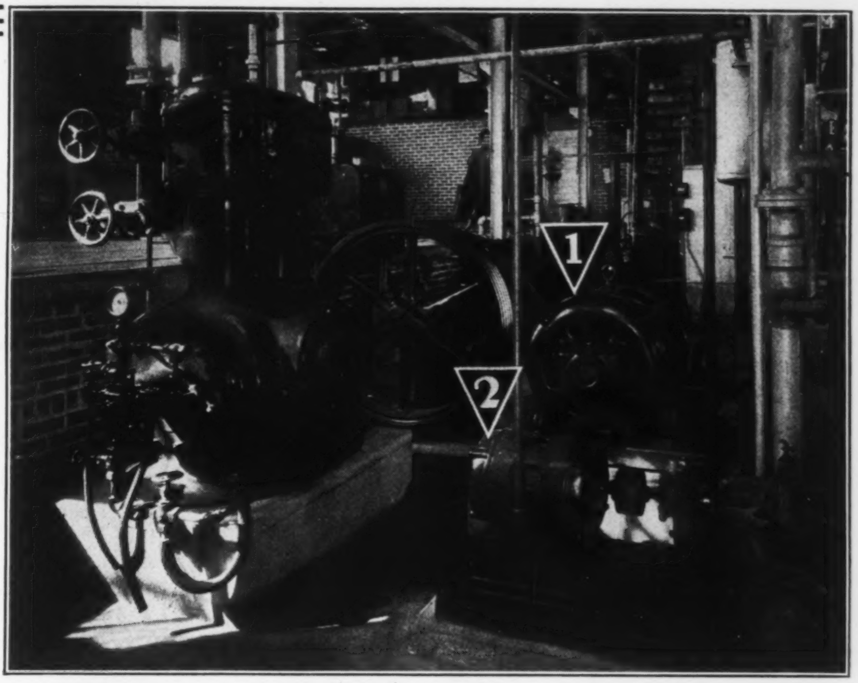
* * *

Technical Committee Clarifies Book

Writing in *Industrial Standardization*, L. S. Marsh, Inland Steel Co., Chicago, reports progress for the technical committee of the American Iron & Steel Institute, of which he is chairman. The group formed in 1933, found a necessity for a thorough study of the various sections of the book of "Uniform Extras and Deductions for Products of the Iron & Steel Industry under the Code of Fair Competition." This

1 *Century 60 HP, Type SCH Squirrel Cage Induction Motor, V-Belt Connected to Compressor.*

2 *Century 5 HP, Type SC Squirrel Cage Induction Motor Direct Connected to Pump.*



A Leading Part in Air Conditioning

Refrigerators... Compressors... Pumps... Fans... Blowers... Ventilators — in driving this and similar air-conditioning equipment Century Motors play a leading part. Many of them have been steadily on the job for more than 30 years — all of them set a conspicuous record in meeting the service requirements so essential in air-conditioning and refrigeration installations . . . Consult Century Engineers.

Single Phase...Polyphase...Direct Current...Single Speed, Multi-Speed — 1/250 to 600 Horse Power.

CENTURY ELECTRIC COMPANY
1806 Pine Street , , , St. Louis, Mo.
Offices and Stock Points in Principal Cities

Century 3 Horse Power, 60 Cycle, Ball Bearing, Flange Mounting Splash Proof Motor.

Century 60 Horse Power, 1220 r.p.m. 60 Cycle, 220/440 Volt, Squirrel Cage Induction Splash Proof Motor. Two-way Ventilation.

Century
MOTORS

study has been made to correct errors, change the phraseology where the intent might not be clearly understood, and make such additions as seemed necessary for a clearer understanding of the details, particularly with reference to qualities, grades and specifications.

* * *

Welding Exhibit Contributed

Complete equipment for a permanent exhibit of industrial welding has been presented to the Museum of Science and Industry in Chicago. The contribution, made by a prominent Milwaukee manufacturer, forms a unique exhibit. With demonstrations carried on behind a special colored glass visitors are able to view at close range the technique employed in various types of welding without blinding glare.

* * *

Autogiro Undergoes Refinement

Entirely wingless and with a rotor that has only two blades, a new autogiro recently underwent tests at Hanworth, England. Safety features include an expanding brake inside the hub of the rotor to stop it spinning after the craft has been grounded. A mechanism is provided which throws out the clutch and releases the wheel brakes simultaneously so that the machine cannot be taken off the ground with the control column in locked position.

* * *

Measuring Fog Density by Photo-cell

Fog density is measured by a device invented by Prof. Karolus of the University of Leipzig. He demonstrated it recently at the meeting of the German Geophysical society. When the light ray passing between sender and receiver is modified or obscured by even a slight mist intervening between two instruments, the electrical waves set up in the photo-cell are correspondingly modified and may be read off directly on an electroscope. Difference between this reading and what it would be if the light ray had passed through clear air indicates the density of the fog.

* * *

Electrically Operated Scoreboard

A unique electric scoreboard, the first of its kind to be controlled and operated by wireless communication with the sidelines, has kept spectators in close contact with the field of play during football games at University of Detroit stadium. This method of communication for use at the games was originated by Prof. H. O. Warner, head of the electrical engineering department at the university. A huge clock built by General Motors research division and dominating the top of the scoreboard, is designed to act as the official timepiece for the games.

The board is operated by a crew of five men wearing telephone headsets, by which they keep in intimate touch with all developments on the field, reported by an observer on the sidelines carrying a portable induction phone. This phone requires no direct wire connections between the transmitter and the receiver. The observer speaks into the telephone transmitter connected to a coil of wire worn around his waist and energized by pocket batteries. The electrical vibrations in the coil induce corresponding fluctuations in parallel wires buried along the sideline of the gridiron.

* * *

Airliner Piloted Mechanically

Operated electrically and hydraulically, apparatus which can pilot a large airliner without human control is said to have been developed in Germany. The device, according to reports, converts tiny impulses set up by a compass, airspeed indicator and inclinometer into forces that actuate the controls. When the engine fails, it automatically puts the plane into a glide.

* * *

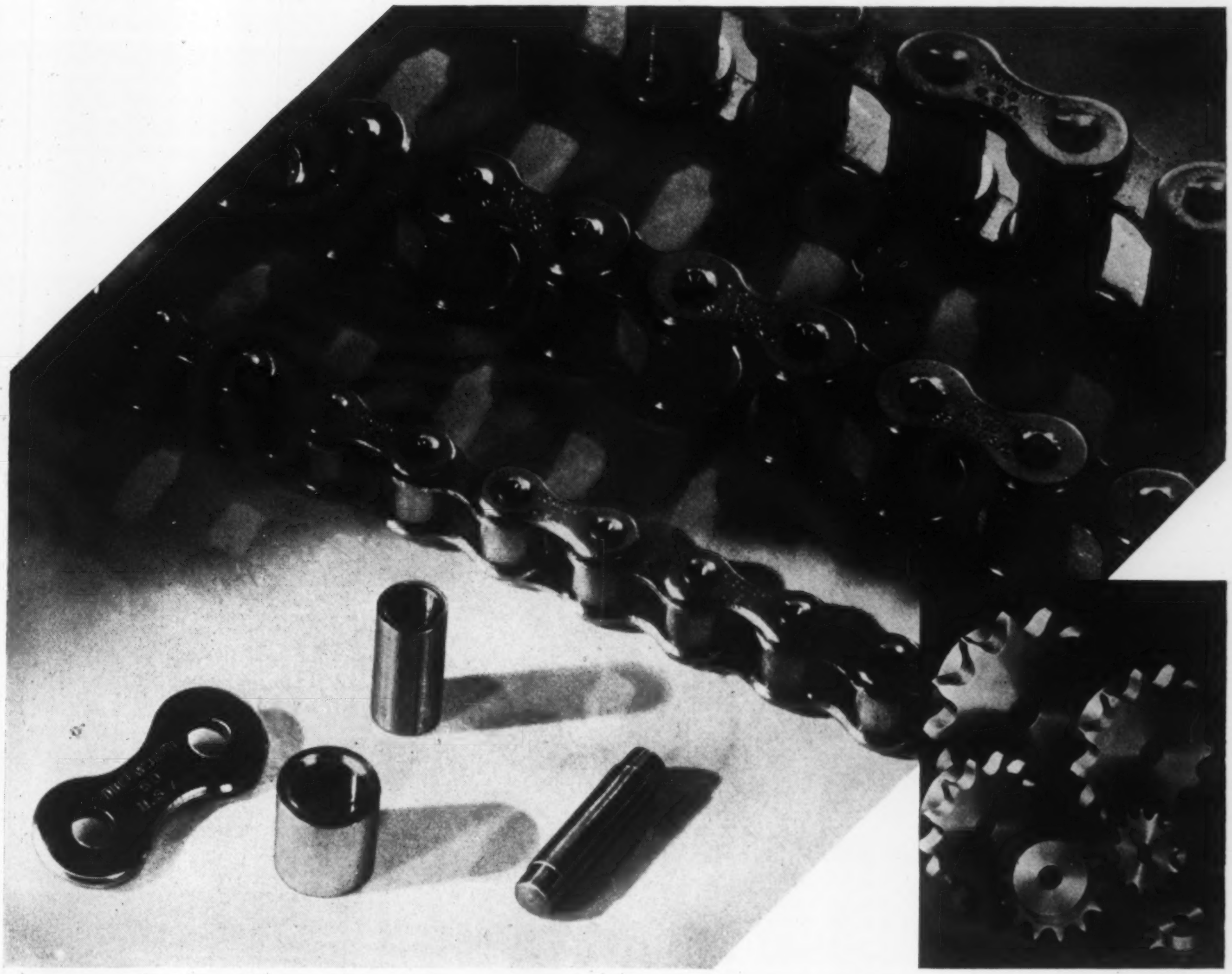
Railroads Staging Comeback

Evidence that further strides are being made in railway equipment development was revealed recently when orders for fifty-seven streamlined electric locomotives were placed by the Pennsylvania railroad. Almost $15,000,000 will be invested. Cabs will be located in the middle of the engines to provide additional safety for the operators. Other features include a maximum starting tractive effort of 72,800 pounds and speeds up to ninety miles an hour.

* * *

Establishes Memorial to Designer

New York university recently received a gift of $1000 from Mrs. Annie E. Vought, Forest Hills, L. I., to be used as a memorial to her son, the late Chance Vought, noted pilot, aeronautical engineer and aircraft manufacturer. Income from the gift will be used to establish an appropriate prize in the Daniel Guggenheim School of Aeronautics, which will be awarded annually to the senior or graduate student in aeronautical engineering who produces the best design for an airplane of given specifications. Mr. Vought, who died in 1930 at the age of 40 years, was an alumnus of New York university college of engineering. Among his outstanding achievements was the development of a navy two-seater torpedo plane designed especially for catapulting from warships or operating from carriers.



Properly designed and accurately cut sprockets such as these lengthen chain life materially. You will find Baldwin-Duckworth sprockets a practical investment.

Who says PRAYERS AREN'T ANSWERED?

One gentleman of our acquaintance will gladly uphold the affirmative—any time. And he can prove his contention by the very roller chains pictured here.

An important machine operated under conditions so conducive to corrosion that he felt standard roller chains would never be able to stand the gaff. When he threw the problem in our lap, his "prayer" was no less heartfelt for being a little profane.

We were able to end his troubles by specifying the bronze chain, illustrated here, which has high fatigue limit, unusual tensile strength and wearing qualities—yet resists corrosion indefinitely. We did this at relatively low cost because we have developed the use of alloys of various properties (in this case, two special bronze alloys) which can be economically machined.

Many situations arise in modern machine design that cannot be handled with standard equipment. This is often true of roller chains. Bring the unusual situation to Baldwin-Duckworth and permit us to make recommendations based on our extended experience in the design and manufacture of special chains. We carry in stock bronze and stainless steel roller chains in numerous sizes for handling just such situations.

Sometimes, as in this case, the solution is one of materials. Sometimes it's size and type. Often it is one of special design all the way through.

Whatever the need, you will find our special Service Department practical, efficient and easy to work with.

BALDWIN-DUCKWORTH CHAIN CORPORATION
365 Plainfield St., Springfield, Mass.

BALDWIN DUCKWORTH

Factories at Springfield and Worcester, Mass.

NEW MATERIALS AND PARTS

Motorized Reducers Are Streamlined

MOTORIZED speed reducers streamlined for appearance and produced with an attractive crinkle finish have been designed by Janette Mfg. Co., 556 West Monroe street, Chicago. One frame size is used for all standard gears ranging from 286 to 0.19 revolutions per minute in these reducers, shown herewith, and for all motors from 1/50 to 1/20 horsepower. In the design, the countershaft is parallel to the motor shaft. Spur gears used are mounted on hardened steel pins. Pinions are held rigidly to the gears by broaching holes in the gears and inserting the pinion teeth. A composition gear is used on the first cluster for quietness.

Reducers can be operated in either a vertical or a horizontal position with motors of many different characteristics

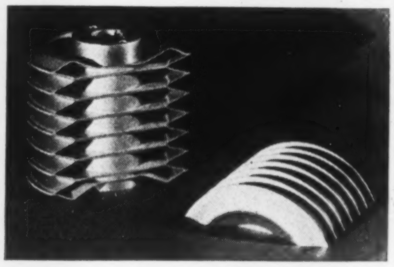
The reducer can be operated in either a vertical or horizontal postion. Motors can be furnished in split phase alternating current, shunt or compound wound direct current and series wound direct current, three-wire reversible type motors for continuous duty service. Also series type alternating current, three-wire reversible and universal motors for intermittent duty service are available.

Filters Handle Many Substances

PUROLATOR filters in a new line which has been tested commercially in the filtration of many substances including coolants on lathes and grinders, cup greases, compressed air, gasoline, paints, varnishes and lacquers, refrigerating fluids, food products and even acids are being offered by Motor Improvements Inc., 365 Frelinghuysen avenue, Newark, N. J. These filters range in size from units no more than two inches in length by half an inch in diameter to castings nearly six feet in length and more than half this much in diameter.

Sheaves Are Reinforced

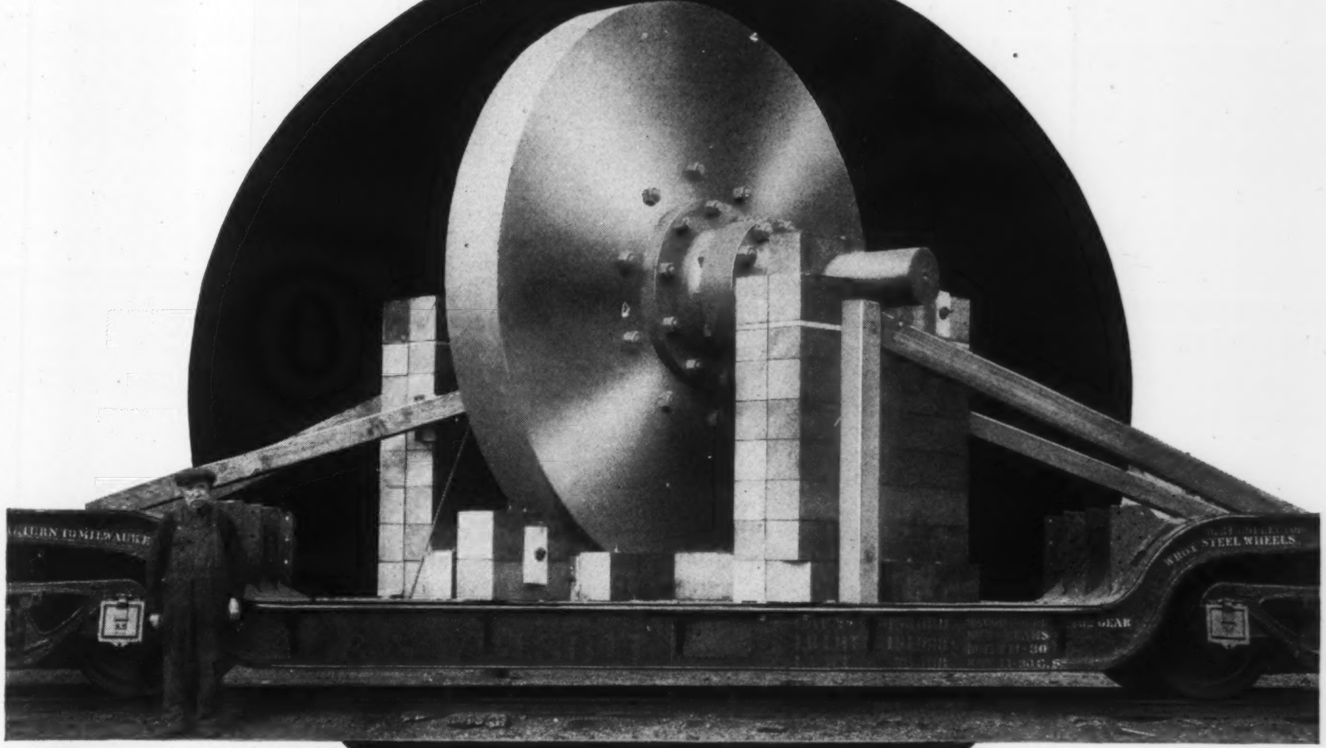
REINFORCED steel sheaves have been brought out by Allis-Chalmers Mfg. Co., Milwaukee, under the name of Duro-Brace Texsteel Sheaves. Outside walls of sheaves sometimes bend under the strain of excessive overloads, with the result that they are thrown off true. The outside walls of the new sheaves, shown herewith, are reinforced by a convex steel plate which strengthens these vulnerable areas so as practically to eliminate the possibility of distortion. The sheaves are welded at the rim and web, for additional strength, while the interior is of grid-type construction, selected for rigidity.


Outside walls of sheaves are reinforced by a convex steel plate

Electric Brakes Are Compact

COMPACT, smooth-acting, disk-type electric brakes designed for mounting directly on a number of types of motors have been announced by General Electric Co., Schenectady, N. Y. The new brake, shown herewith, is intended especially for controlling small hoists, cranes, winches and similar equipment. It is suitable for applications requiring no more than 50 pounds-feet braking torque on a continuous basis, or 75 pounds-feet on an intermittent basis.

The brake is obtainable, completely mounted



FLYWHEELS

FABRICATED FROM STEEL PLATES

● Flywheels up to fifteen feet in diameter and thirty-two tons in weight have been successfully fabricated from rolled steel plates. Here illustrated is the flywheel for a 1000 H.P., 2200 volt A.C. Flywheel induction motor generator set.

Production time and costs are reduced with this type of construction. The flywheel is protected from the danger of internal defects.

For flywheels and for large gears, rolled steel is coming into wider and wider use, just as it has in the fabrication of engine and machine bases and frames.

Designers and engineers seeking specific data regarding standard shapes and sections of rolled steel will find the Illinois Shape Book a valuable manual. A copy of this 280-page book will be sent upon request.

ILLINOIS
SHAPE BOOK

The Illinois Shape Book belongs in every modern engineering or design department. Write today for a copy of this 280-page book containing profiles and physical data on a wide variety of rolled steel products.

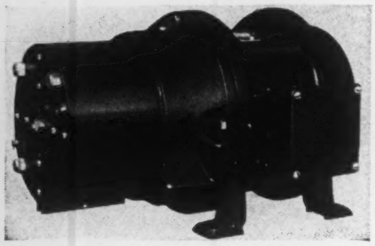
ROLLED STEEL OFFERS THESE ADVANTAGES

1. Cheaper . . . for most parts.
2. Reduces loss due to defects or discards.
3. Permits inexpensive changes in design.
4. Faster production . . . particularly of new and unstandardized parts.
5. Reduces inventory and pattern storage.
6. Permits prompt adaptation of standard design to special requirements.
7. Eliminates excess weight.
8. Modernizes appearance.

Illinois Steel Company
208 SOUTH LASALLE STREET, CHICAGO, ILL.
SUBSIDIARY OF UNITED STATES STEEL CORPORATION

US STEEL

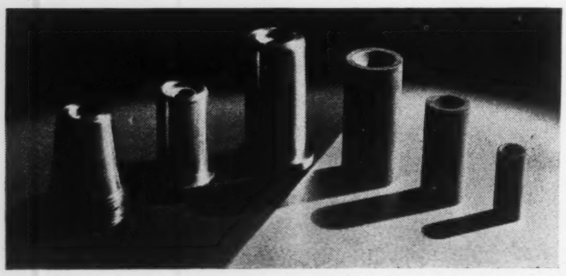
and wired, as a shipped-assembled unit on ball bearing, squirrel cage, wound rotor or single phase and direct current motors in the NEMA frames. The motor may be open splash proof; totally enclosed, nonventilated; or explosion proof, nonventilated—having electrical characteristics designated according to nine different types. The brake also is available separately and may be adapted to floor mounting. In construction, the new device is somewhat similar to an automobile clutch of the multiple disk type.



Disk-type electric brake is designed for mounting directly on a number of different types of motors

Material Has Extreme Hardness

A NEW material with a hardness approaching that of the diamond has been developed by Norton Co., Worcester, Mass., and now is available for many industrial applications. The material, boron carbide, is an electric furnace product made similarly to silicon carbide, and has a hardness of 14 on a modified Moh scale on which silicon carbide is rated 13 and the diamond 15.



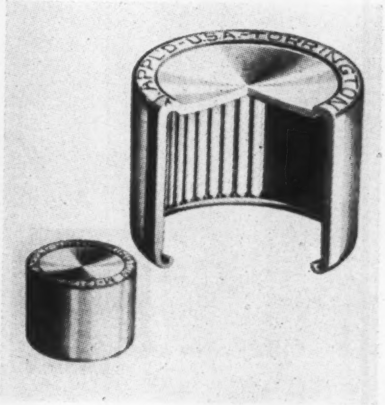
Abrasive blasting nozzles and liners are available in new hard material

The material, according to the manufacturer, is unaffected by the strongest acids and alkalies, has a compressive strength of 260,000 pounds per square inch, a coefficient of expansion of approximately two-thirds that of steel, is little affected by temperatures up to 1832 degrees Fahr. at which the diamond burns completely, and is lighter than aluminum.

Industrial applications of boron carbide depend entirely on its intrinsic hardness and include uses as a wear resisting material and as an abrasive. One important use is that for the construction of abrasive blasting nozzles. Other applications are molded jewel-type bearings, wire drawing dies, inserts, thread guides, etc. for wear resistance.

Improves Needle Bushings

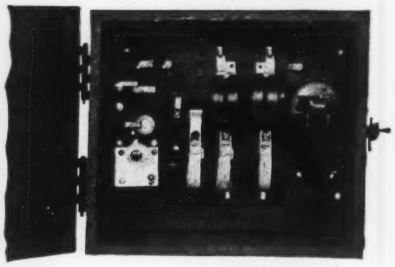
NEEDLE bushings with closed ends for applications where the bearing would be on the end of a shaft have been developed by Torrington Co., Torrington, Conn. In such applications the closed end bushing, shown herewith, has advantages as the one-piece outer shell raceway is closed at one end, thereby facilitating the retaining of grease and oil during the operation of the running unit. In general construction the bushing is the same as that described on page 52 of the September, 1934, issue of MACHINE DESIGN.



Closed end needle bearings will retain grease and oil during operation

Offers Improved Weld Timer

FOR AUTOMATICALLY timing the power supply to resistance welders by controlling the contactor on the welder, General Electric Co., Schenectady, N. Y., has introduced a new synchronous-motor-operated timer. The timer is easily and accurately set for the time most suitable for the work at hand, and, once set, the time is unaffected by line-voltage variations or



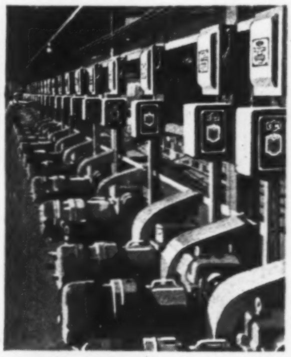
Synchronous-motor-operated timer automatically controls power supply to resistance welders

POWER OUT OF CONTROL ALWAYS MEANS *Waste*

YET *INDUSTRY'S DAILY TORNADO* OF *Power-out-of-Control* DOESN'T MAKE THE HEADLINES

When the occasional tornado leaves a trail of waste, it's headline news. And yet every working day, America pays a bigger bill for another kind of power-out-of-control that passes practically unnoticed.

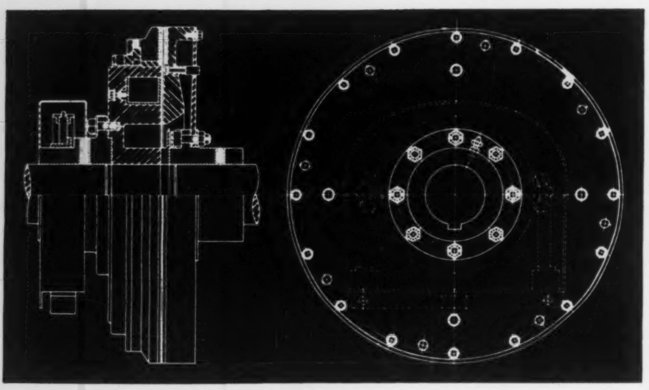
Electric motors, like the forces of nature, are merely so much raw power. How well they serve or how much they waste depends largely on how well they are *controlled*. This is the key to the importance of Cutler-Hammer Motor Control. Knowing executives say nothing justifies substitution for Cutler-Hammer performance. So widespread is this recognition of Cutler-Hammer superiority that many outstanding builders of motor-driven machines standardize on Cutler-Hammer Motor Control and actively feature it in their selling. The majority of electric motor manufacturers recommend it. Leading independent electrical wholesalers stock it for your convenience. Be sure your plant capitalizes the importance of Motor Control. Specify Cutler-Hammer for every motor or motorized machine. CUTLER-HAMMER, Inc., *Pioneer Manufacturers of Electric Control Apparatus*, 1310 St. Paul Ave., Milwaukee, Wis.



This is the sixth of a new series of Cutler-Hammer advertisements in national magazines. Has appeared in Nov. 5 TIME; and appears in December FORTUNE. C-H Motor Control, most widely advertised, is a definite sales asset for any motorized machine. Standardize on Cutler-Hammer to speed your selling and assure the utmost in performance. C-H Machine Designers' Motor Control Manual supplied at no cost when requested on company letterhead. (B265)

CUTLER HAMMER

THE CONTROL EQUIPMENT C-H GOOD ELECTRIC MOTORS DESERVE



A NEW
Magnetic Clutch
***with very low* W R²**

HERE is the answer to the synchronization and mechanical or electric braking problems on presses and other heavy machinery involving accurate synchronization and quick stopping.

The driven member of the new Dings Magnetic Clutch has a very low W R². It is of steel construction throughout and through the use of special alloy steel with high permeability and low residual magnetic quality quick action of both engagement and disengagement is assured.

Torque is unusually high and unusually light weight with a combination of great strength has been secured.

As the friction linings extend to the outside diameter they are large in area. Cool operation is secured by a special exclusive serrated design. Adjustment for wear is made by a positive method and wear can be checked at any time by a practical clearance feeler.

Friction surfaces cannot be reached by lubricating materials.

The magnet hub is removable with the minimum amount of horizontal movement and the magnet coil is positively anchored on an aluminum bobbin. A dust-proof housing protects the slip rings and brushes and the brushes are of the double contact type.

It is simple, positive in action and is backed by the long experience of engineers specializing in magnetic equipment.

Every designing engineer should have information on this clutch in file.

EXPERIENCE
that saves money

No other manufacturer can offer you the years of experience in the building of magnetic equipment that is Dings'. Since 1899 Dings engineers have been solving separation, magnetic protection and power transmission problems, supplying the major needs where magnetic equipment is required.

This experience is your assurance of dependable advice, helpful cooperation and a proved product. There is no cost in taking advantage of it.

DINGS MAGNETIC SEPARATOR CO.
666 Smith Street, Milwaukee, Wisc.

Dings
High Intensity
MAGNETIC
CLUTCHES

surges. If adjusted for welding two thicknesses of metal, the control will provide satisfactory welds when several thicknesses of metal are placed between the electrodes—no change in timer or welder setting is required in application of the unit.

Announces Flexible Aluminum Paint

FLEXIBLE aluminum paint which gives a scale-like metal sheathing for longer protection, plus a smooth, brilliant finish has been perfected by Roxalin Flexible Lacquer Co., 800 Magnolia avenue, Elizabeth, N. J. Dirt and dust do not attach themselves readily to the surface of the paint. Because of water resisting qualities (including salt water) the surface can be washed frequently without damage. The paint also displays resistance to chemical fumes, humid atmospheres, corrosion, rust and decay, and similar forces.

Centrifugal Compressors Are Compact

A NEW, compact centrifugal compressor (turbo-blower) which incorporates a gearmotor as an integral part of the design has been developed by Allis-Chalmers Mfg. Co., Milwaukee. By using the gearmotor for speed increase, the blower can run at higher than motor speeds, thus reducing dimensions required for the prime mover and improving performance.

Pressures from 0.75 pounds G. to 3.0 pounds G. are developed by the compressors, the volumetric capacities corresponding to motor outputs from 3 to 30 horsepower. The units have application for foundry cupola blowing, oil and gas fired furnaces, pneumatic conveying, agitation and aeration, and for similar moderately low pressure air or gas supply services.

Weld Timer Is Automatic

FOR USE in connection with resistance welding machines in which the electrodes of the welder are air or motor-operated, Electric Controller & Mfg. Co., 2702 East Seventy-ninth street, Cleveland, has announced a new automatic repeat weld timer.

The new timer is the same as the standard automatic weld timer manufactured by the company, except that it has an additional timing circuit for governing the length of time the electrodes of the welding machine are separated to allow the work to be moved to the position where the next weld is desired. The "welding-period" provided by this timer varies in inverse propor-

Design for OXWELDING

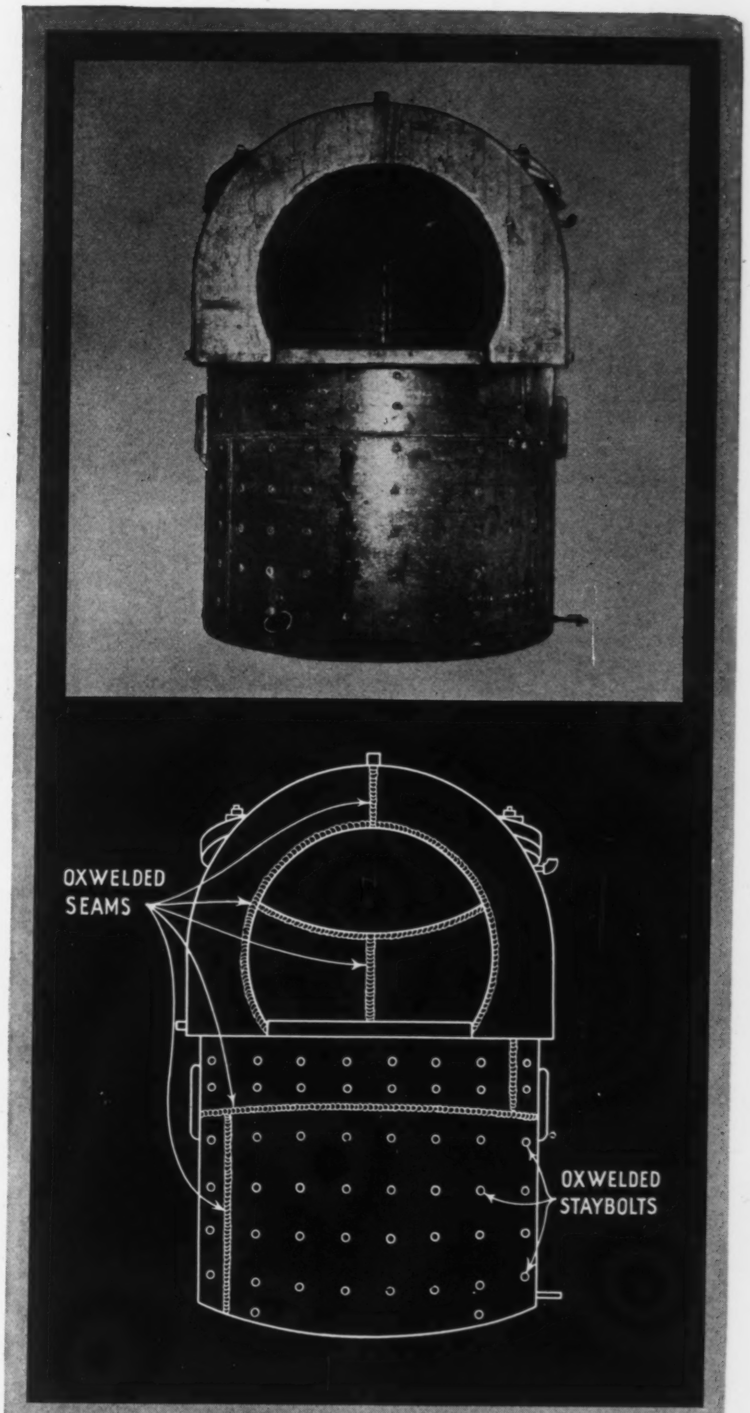
get Strength with Simplicity

A PAPER manufacturer needed a number of alkali recovery furnaces built for several mills. Unsatisfied with previous designs because of inherent weaknesses requiring bulky reinforcement of the joints, the chief engineer called on Linde Process Service to help redesign for oxwelding.

The oxwelded butt joint, which Linde recommended, was adopted for the new design and specifications were prepared for oxy-acetylene welding with High Test steel welding rod. This joint, by developing the full strength of the base material, permitted design changes which made the furnace more efficient and easier to operate and maintain.

Design for oxwelding also gave greater strength and heat resistance, less weight and bulk, more rigidity, and simpler and speedier fabrication.

Does your product need these features? If so, the trained Linde representative, who will call at your request, may be able to assist you in its design or redesign. The nearest Linde Sales Office will be glad to explain this service to you, and to suggest where you can utilize the oxy-acetylene process profitably.



Linde Process Service helped to make this a better furnace. With strong, oxwelded joints its fabrication was simplified. New design features such as the flat top and oxwelded staybolts to make the double wall shell rigid were incorporated without increasing the cost.

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

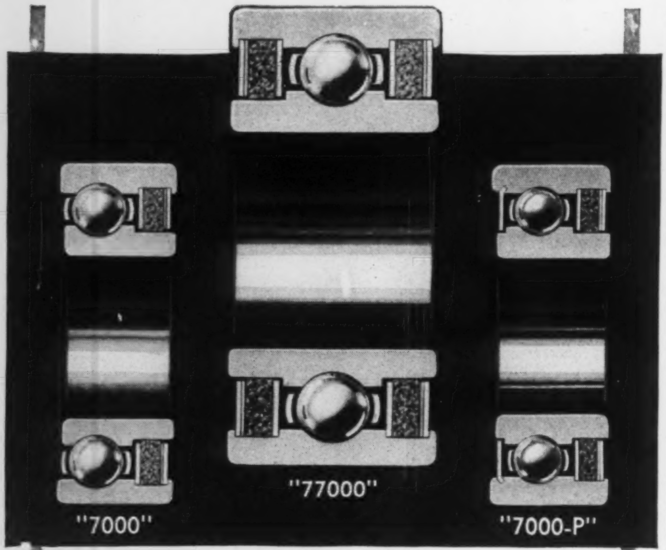
UCC

NRA CODE

Sales Offices: Atlanta Baltimore Birmingham Boston Buffalo Butte Chicago Cleveland Dallas Denver Detroit El Paso Houston Indianapolis Kansas City Los Angeles Memphis Milwaukee Minneapolis New Orleans New York Philadelphia Phoenix Pittsburgh Portland, Ore. St. Louis Salt Lake City San Francisco Seattle Spokane Tulsa

IN CANADA, DOMINION OXYGEN CO., LTD., TORONTO

LINDE OXYGEN ▪ PREST-O-LITE ACETYLENE ▪ OXWELD APPARATUS AND SUPPLIES ▪ UNION CARBIDE



SELF-SEALED

The "GREASEAL" Series of Felt-Protected Ball Bearings—in the three types illustrated above—is marked by the following outstanding features which make for better performance and more lasting satisfaction:- thick, closely-fitting felts between removable plates forming an effective labyrinth against the recessed inner ring - - - FELT SEAL REMOVABLE in its entirety for inspection, cleaning or renewal of grease - - - wide, solid inner and outer rings, with maximum contact on shaft and housing, make inserts in housing unnecessary and militate against slippage, looseness, and escape of lubricant past outer ring - - - felt seal within confines of both rings and not exposed to injury - - - constructional characteristics assuring dimensional exactness and quiet running - - - grease capacity ample for long periods of service - - - important features of design covered by basic patents. . . . These three "GREASEAL" types, together with many others in the PRECISION line, constitute THE MOST COMPLETE LINE OF SELF-PROTECTED BEARINGS IN AMERICA. Write for the Catalog. Let our engineers work with yours.

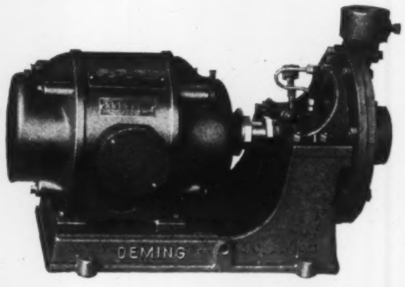
NORMA-HOFFMANN BEARINGS CORPN.
STAMFORD, CONN., U.S.A.

NORMA-HOFFMANN
PRECISION BEARINGS
BALL, ROLLER AND THRUST

tion to the rate of current flow, insuring that the correct number of heat units are put into each weld, while the "off-time," or period the electrodes are apart, is adjustable.

Announces Centrifugal Pumping Units

CLOSE-COUPLED, side suction centrifugal pumping units in a new line have been placed on the market by Deming Co., Salem, O. The outstanding feature of the line resides in the fact that any make of standard ball bearing motor of the open, enclosed, splash-proof or explosion-proof type can be used. Pump and motor, shown herewith, are mounted on a single base plate, eliminating any unbalanced overhang of pump or motor. The cradle mounting of the pump permits expansion when handling hot liquids without disturbing the alignment of the unit.



Centrifugal pump with closed bronze impeller is mounted directly on the shaft of the motor

Screws Have Continuous Fibers

SOCKET screws which have continuous, uncut fibers, neither severed or broken, from one end of the screw to the other are being offered by Holo-Krome Screw Corp., Bristol, Conn., under the trade marked name Fibro Forged Screw. The continuous fibers give increased strength in all portions of the screw where strength is most needed. In combination with this development, the company features controlled grain size and atmospherically controlled electrical heat treatment.

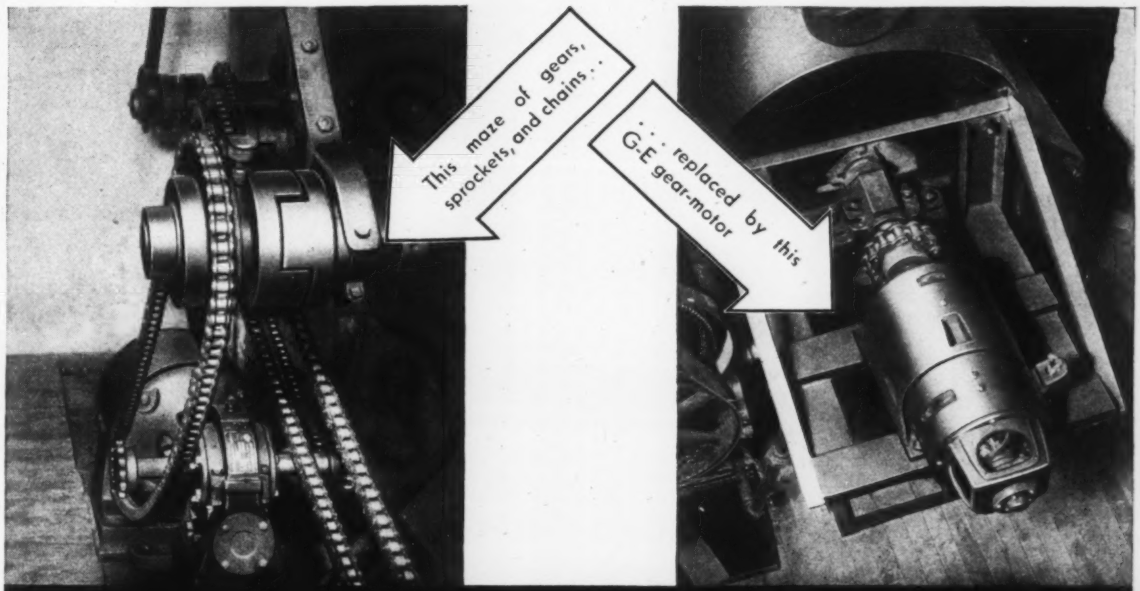
Announces New Weld Timer

A PORTABLE ignition welding timer, for accurate timing of all types of resistance welding machines, has been announced by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. The timer will pass electrical current for periods as short as one cycle (1/60 second) and is adjustable up to 30 cycles (½ second). Outside of

SAVED POWER MAINTENANCE SPACE

with this G-E Gear-Motor

BEFORE AFTER


This maze of gears, sprockets, and chains . .
. . . replaced by this G-E gear-motor

More proof that G-E gear-motors will simplify your low-speed drive problems, will cut your maintenance costs and save space

BEFORE modernization, a 5-hp. motor in the Kelly Company's plant, Cleveland, operating through the complicated system of gears, chains, and sprockets shown in the left-hand picture, was required to drive a pair of peanut roasters.

Now, a smooth-running, low-upkeep, *one-horsepower* G-E gear-motor, direct-connected to each roaster as shown in the right-hand picture, does the job. Consider the savings in power, maintenance, and space —not to mention the increased flexibility—that this gear-motor makes possible.

You, too, will find it profitable to use these compact, efficient G-E gear-motors wherever you need a thoroughly dependable low-speed drive. They're built to stand the gaff of the hardest service—built to stay on the job year after year.

G-E gear-motors are available in standard voltages and ratings from 1/6 to 75 hp., from 11 to 600 rpm. To meet your special needs, various mechanical and electrical modifications can be supplied. For complete information, address General Electric, Dept. 6C-201, Schenectady, N. Y.

020-58

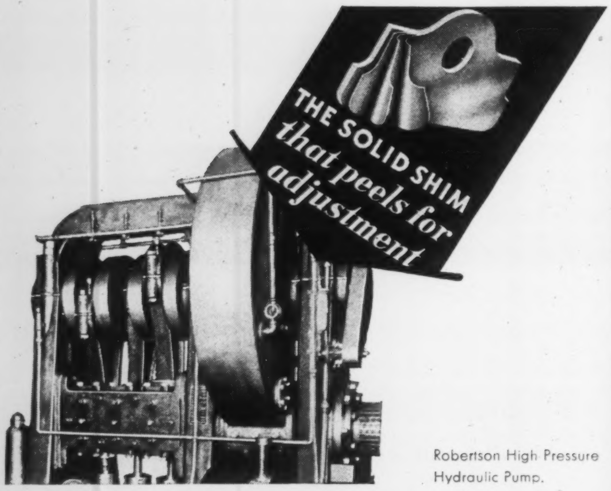
GENERAL ELECTRIC

Have You Seen Dumore's Low-Priced Gear Reduction Motor?

If you are looking for a low-priced gear reduction motor, consider the Type EEXQ illustrated. . . . It has Dumore dynamic balance and Dumore reliability. Available for any voltage. Gear shaft speeds — 533, 266, or 200 R. P. M. Compact, with plenty of power, this motor is ideal for electrically driven games, signs, etc. . . . It is only one of 64 standard types and sizes of Dumore Motors. Put your motor problem up to the Dumore Engineering staff.

DUMORE COMPANY 100 Sixteenth Street Racine, Wis.

DUMORE
FRACTIONAL HORSEPOWER
MOTORS



Robertson High Pressure Hydraulic Pump.

● quick, accurate adjustment for crankshaft, connecting rod and Timken bearings

Laminum shims provide easy, *accurate* adjustment during the life of this Robertson pump. You simply p-e-e-l the laminated brass .002" or more at a time down to the precision thickness desired.

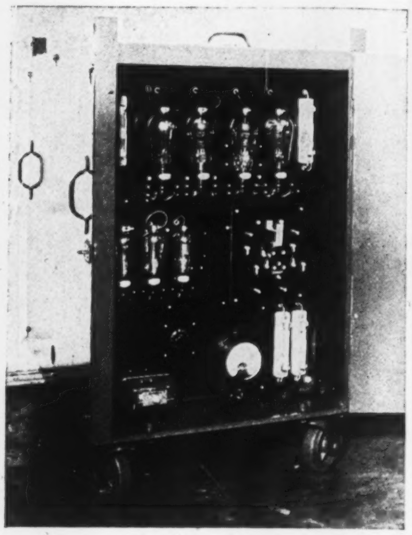
No filing! . . . No skill required. No miking! . . . although if you do mike Laminum you'll find it more accurate and more uniform than filed shims. *No wonder they cost less to use.*

LAMINUM

LAMINATED SHIM COMPANY, INC.
2126 Forty-fourth Ave., Long Island City, N. Y.

531

its electrical advantages over former types, the new timer, shown herewith, is light in weight and small in dimensions. It is only 46 inches high, 42 inches long and 29 inches wide, and weighs approximately 700 pounds. A unit of this size will carry electrical energies in magnitudes as high as 700 kv-a., 440 volts single phase.



Portable welding timer is light in weight and small in dimensions for its capacity

Potential Markets Affect Today's Developments

NEW industries, new processes and new uses for present products— these, according to a well known business leader, are the cures for many present-day industrial ills. Evidence that industrial trends support this statement is contained in "Product Development," a new report issued by the policyholders' service bureau, Metropolitan Life Insurance Co. An increasing number of manufacturers are turning to machine development or improvement, the report points out, as a means of stimulating sales and enlarging profits. Development today is concerned not only with mechanical excellence, it is stated, but also with potential markets and with qualities in the product that will meet the desires of consumers.

Search Is Organized

Through the co-operation of 75 companies representing a cross section of industry, current practices with reference to product development are described. The report tells how these 75 companies have organized their search for new machines and their procedure for perfecting them in accordance with the preferences of consumers.

Sales or service men are found to be a fertile source of ideas, probably because of their close contact with users. Other companies obtain suggestions from general employes which have been found useful in developing new ideas. A prominent manufacturer of automobiles goes direct to the consumer, on the theory that "there is only one person qualified to say just what the motorist prefers and that person is the motorist himself."

Marketing Possibilities Considered

The survey revealed that many companies, in the selection of ideas for development, give attention to such considerations as: Whether the machine is suitable for marketing to established sales outlets, whether it can be fabricated with existing plant and equipment, whether it will overcome seasonal dullness, and whether the potential market is worth cultivating.

The survey emphasizes the need of organization and systematic procedure. Research and development work in the companies surveyed is found to be usually under the direction of an officer, often ranking with the executive in charge of production and sales. The use of a technical research organization consisting of chemists and engineers was found to be common in larger organizations.

Copies of the report may be obtained by addressing the policyholders' service bureau, Metropolitan Life Insurance Co., 1 Madison avenue, New York.

Overcoming Shaft Fatigue at Fitted Units

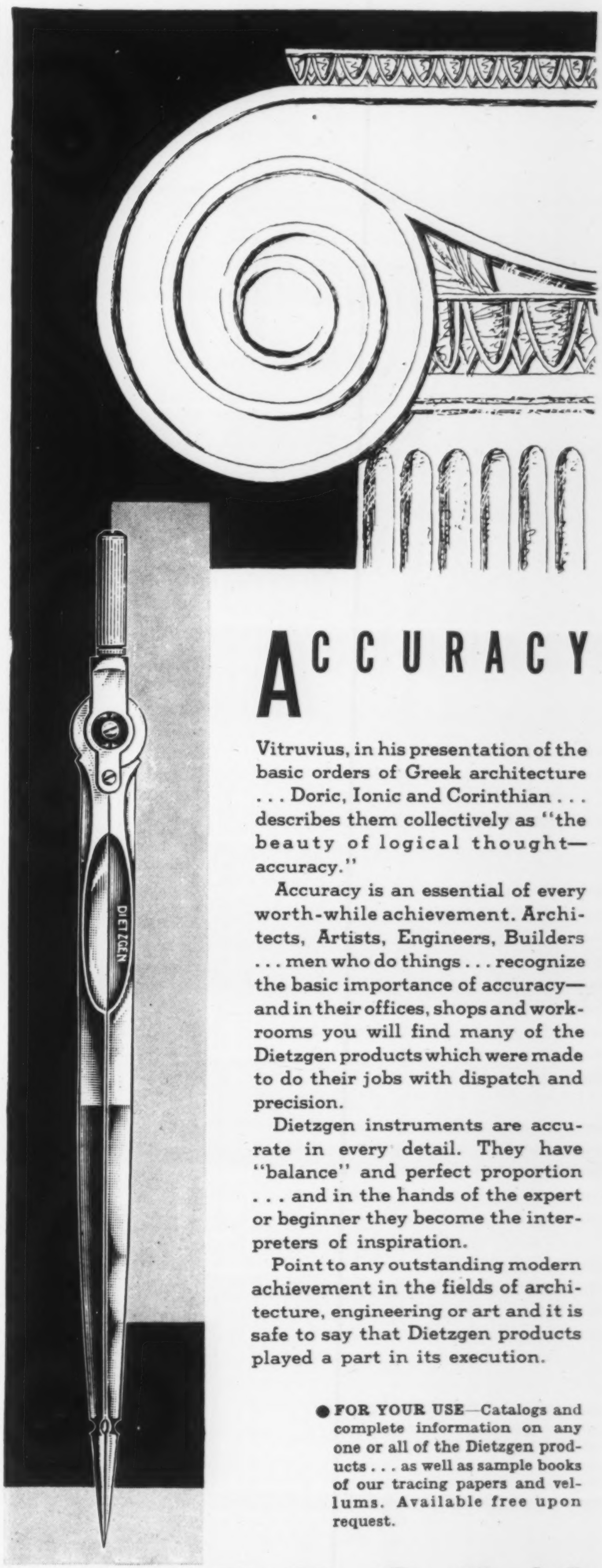
(*Continued from Page* 27)

press fit pressure. Fringe photographs for this case are shown in *Fig.* 6, top.

Case 2. *Plain Press Fit with Edge Beveled Off (Fig.* 2c*), the Nominal Stresses being as in Case* 1. This bevel was made by taking a very light cut to simulate the wear which occurs at the edge due to rubbing corrosion under continuous fatigue stressing. The photograph for this case is shown in *Fig.* 6, center.

Case 3. *Press Fit with Grooved Construction (Nominal Stresses as in Case* 1). This piece was tested to determine the effect of the groove in reducing the stress concentration, the fringe photograph being shown in *Fig.* 6, bottom.

Tests made with a special lateral extensometer on the specimen of Case 2, which represents a plain press fit with wear, showed that the stress distribution and also the values of peak stresses were not greatly different from the corresponding results obtained for the tests on the plain press fit without wear (Case 1). Consequently the photoelastic results can be considered to represent approximately the fatigue specimens even



ACCURACY

Vitruvius, in his presentation of the basic orders of Greek architecture . . . Doric, Ionic and Corinthian . . . describes them collectively as "the beauty of logical thought—accuracy."

Accuracy is an essential of every worth-while achievement. Architects, Artists, Engineers, Builders . . . men who do things . . . recognize the basic importance of accuracy—and in their offices, shops and workrooms you will find many of the Dietzgen products which were made to do their jobs with dispatch and precision.

Dietzgen instruments are accurate in every detail. They have "balance" and perfect proportion . . . and in the hands of the expert or beginner they become the interpreters of inspiration.

Point to any outstanding modern achievement in the fields of architecture, engineering or art and it is safe to say that Dietzgen products played a part in its execution.

● **FOR YOUR USE**—Catalogs and complete information on any one or all of the Dietzgen products . . . as well as sample books of our tracing papers and vellums. Available free upon request.

DIETZGEN

Eugene Dietzgen Co., Manufacturers of Drafting and Surveying Supplies
Chicago New York New Orleans Pittsburgh
San Francisco Milwaukee Los Angeles Philadelphia Washington
Factory at Chicago

after some rubbing corrosion has taken place.

In general, it can be said that the fatigue stress concentration factors are closer to the photoelastic stress concentration factors than is ordinarily the case. (Usually the former are considerably less than the latter). This may be due to the fact that in a press fit fatigue test, the shaft material at the point of failure is weakened by rubbing corrosion, and consequently the fatigue stress concentration factor, which would otherwise be lower, is increased.

The reason for the superiority of the grooved construction in the fatigue tests, is due to the elimination of stress peaks at the corners.

High Concentration Found

It will be recalled that fatigue tests on a specimen cut out of a solid bar and having the same contour as the press fit specimens showed a higher fatigue stress concentration factor. A photoelastic test was made to check this and it was found that the solid piece with a sharp corner had higher stress concentration than did the corresponding press fit specimen.

In this examination, an ordinary press fit member was found to decrease the endurance strength of a shaft to roughly half the endurance limit of the shaft material (as determined from specimens without stress concentration). This has also been independently found at two German laboratories. For very light press fit pressures the endurance strength of a shaft is somewhat higher than for heavy pressures.

Rubbing Corrosion Important

German tests indicate that beyond a certain pressure, the endurance strength is independent of pressure. It appears that rubbing corrosion is an important factor in reducing endurance strength.

Two expedients for increasing the endurance strength of shafts with press fitted members, i.e., using a grooved construction, and rolling the shaft surface, were found to be very effective.

Photoelastic tests, combined with a stress analysis showed interesting results of fundamental value. The reason for the effectiveness of the grooved construction was shown by photoelastic tests to be due to reduction of stress peaks at the corners.

Articles on this and allied subjects presented in previous issues of MACHINE DESIGN include:

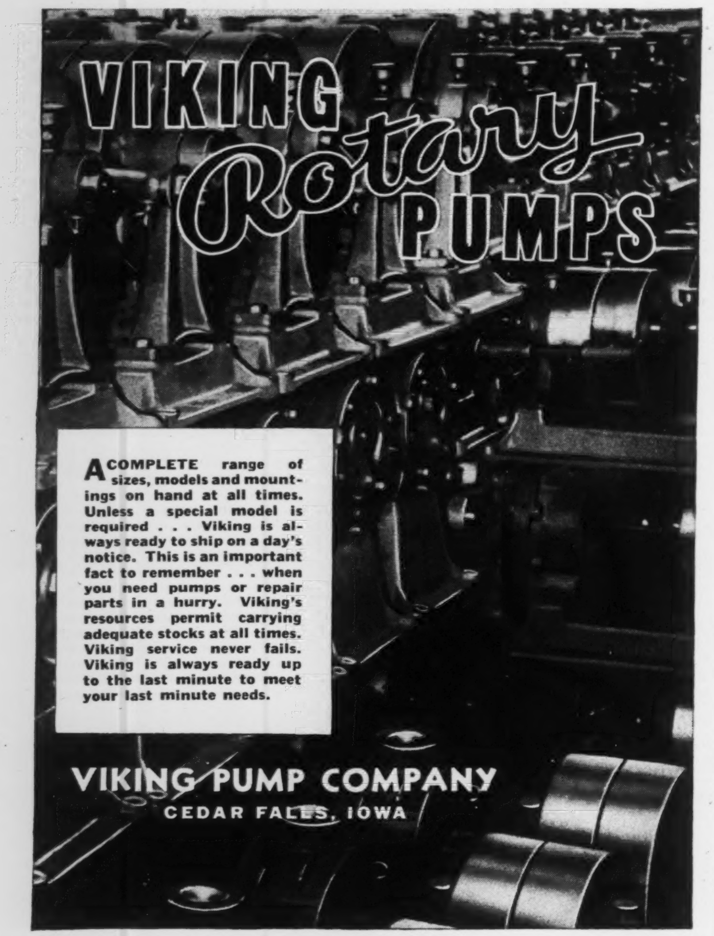
"Study of Fatigue of Metals Yields Data for Machine Design," by H. F. Moore, Nov., 1929, p. 35.

"Metal Creep at High Temperatures," by P. G. McVetty, April, 1931, p. 55.

"Relation of Keyways to Fatigue Failures in Shafts," by R. E. Peterson, July, 1932, p. 36.

"Service Conditions Control Permissible Stress," by C. R. Soderberg, Feb., 1933, p. 27.

"Models Reveal Changes Needed To Combat Fatigue," by R. L. Scorah, Nov., 1933, p. 31.



A COMPLETE range of sizes, models and mountings on hand at all times. Unless a special model is required . . . Viking is always ready to ship on a day's notice. This is an important fact to remember . . . when you need pumps or repair parts in a hurry. Viking's resources permit carrying adequate stocks at all times. Viking service never fails. Viking is always ready up to the last minute to meet your last minute needs.

VIKING PUMP COMPANY
CEDAR FALLS, IOWA

MAIL THE COUPON FOR SOME AMAZING NEWS

CHARLES BRUNING COMPANY, Inc.
102 Reade Street, New York City

Please send me your Free book, "BLACK AND WHITE MAGIC" . . . the book that tells all about Black and White Prints, those positive prints that are made faster than blue prints (without the use of a negative) . . . and that are so much easier to read, check and make notes on.

I UNDERSTAND THERE'S NO OBLIGATION WHATEVER.

NAME__________
COMPANY__________
ADDRESS__________

BRUNING
SINCE 1899
(509)

New Designs Demand Improved Steels

(Concluded from Page 34)

A group of special low-alloy high-tensile steels have been perfected, after considerable research, by United States Steel Corp., New York, and is being offered as USS high-tensile steels. It is claimed that these steels, as given in Table VI, meet in general most or all of the requirements outlined in the introduction of this article, on page 34.

It will be seen that there is a wide range of physical properties available. Cor-Ten is a chromium-silicon-copper alloy steel, low in carbon. It is a patented steel, a feature of which is its high phosporus content. Man-Ten is a medium manganese steel usually containing copper. Sil-Ten is regular "silicon" structural steel to which this copyrighted name has been given.

Corrosion Resistance High

The corrosion resistance of these steels in the atmosphere is pointed to as high, particularly Cor-Ten. Taking ordinary open-hearth as unity or one, the Cor-Ten steel is claimed to have 4 to 6 times the atmospheric corrosion resistance. Man-Ten with copper and Sil-Ten with copper are rated at 2 to 3 times that of ordinary types of steel.

As to weldability, these steels are claimed to be capable of satisfactory welding by any of the usual methods. Suitable coated rods are available for electric welding which will give beads of approximately the same analysis as the base metals and with a corrosion resistance comparable to that of the base metals. Riveting problems are said to be absent.

Tests Show High Impact Values

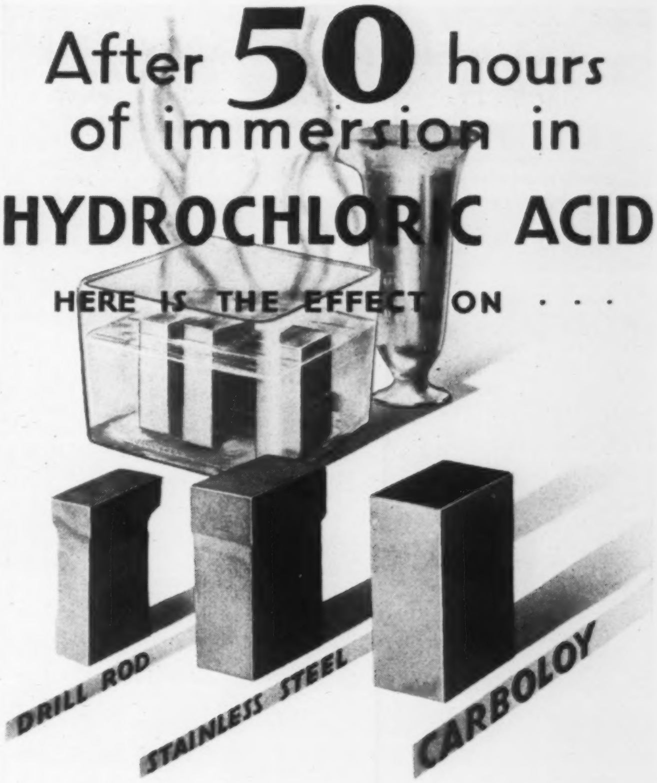
The high impact values of Cor-Ten and Man-Ten are pointed to as features, particularly those of the former. Tests already made show these values to be high also at low temperatures—below zero.

Another quality of these steels is their capability of both cold and hot forming. The extent of the cold forming operations depends on the ductility. In all forming or pressing, it is stated, slightly greater strengths are developed but the hardening is not excessive.

These steels are capable of heat treatment but the results given in the table refer to the as-rolled condition. Heat treatment gives higher strengths. The various grades may be obtained in the soft annealed, or in the hard nonductile condition as-rolled.

After 50 hours of immersion in HYDROCHLORIC ACID

HERE IS THE EFFECT ON . . .



AT the National Metal Exposition in New York City, we immersed a bar of Carboloy, stainless steel and drill rod in a jar of commercially pure hydrochloric acid. After 50 hours of continuous immersion the bars were removed and photographed, as shown above (unretouched).

At the start of the test all three bars were exactly the same size; all three were polished. At the conclusion of the test, Carboloy alone retained its original size and polish, while the comparative effects on the stainless steel and drill rod may be readily seen in the above photo.

This severe test indicates how Carboloy can increase the life of your tools and machine parts which are subject to corrosive wear. Just a small insert of Carboloy brazed in at the point of wear reduces replacement cost, eliminates much costly down-time and increases the quality of your product.

If your parts are subject to either abrasive or corrosive wear, send us a sketch and brief description of the wear factors. We'll gladly furnish full particulars without obligation.

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Now in New, Larger Quarters at
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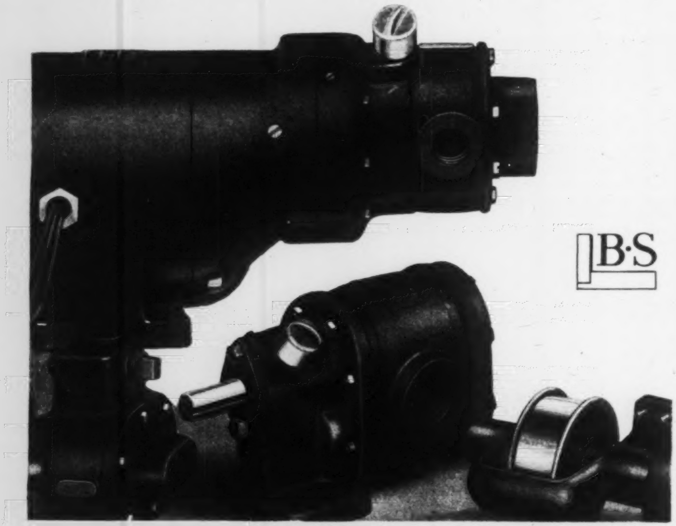
CEMENTED CARBIDE

For Every Installation Requirement

CIRCULATION—COOLANT—LUBRICATION PRESSURE—HYDRAULIC SYSTEMS

Here you can find a reliable pump—of modern design—accurately manufactured and efficient—of a style suited for your requirements.

Learn more about the complete Brown & Sharpe Pump line. Write for circular. Brown & Sharpe Mfg. Co., Providence, R. I.



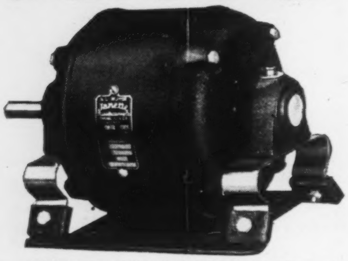
Brown & Sharpe Pumps
Geared — Vane — Centrifugal

Manufacturers and Engineers of Electrical Apparatus for Special Applications

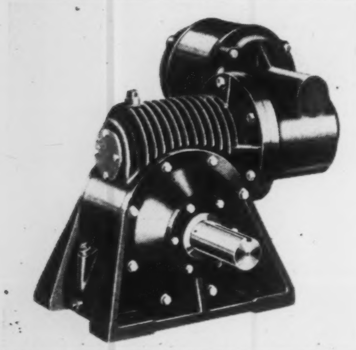
Janette

SPECIAL MOTORS

Janette motors have been noted for years for developing high performance standards. These motors are built for those discriminating manufacturers of motor-driven equipment who believe that their machines are no better or more dependable than the motors which drive them. With this high quality, Janette motors are available at prices which compare favorably with those of motors built to sell at a price basis. Put your special motor application up to Janette.



SPRING MOUNTED MOTOR



Motorized Speed Reducers

In twenty-six distinct types and a wide range of sizes, single and double reduction, 1/50 to 5 horse power. With various mountings, adapted to practically any machine. Entire unit built and guaranteed by Janette. Send for Bulletin 22-1 and 22-33.

Janette Manufacturing Company

560 West Monroe St. Chicago, Illinois

MANUFACTURERS' PUBLICATIONS

ALLOYS (STEEL)—Timken Steel & Tube Co., Canton, O., has published a series of tables which enable the steel user to tell at a glance how long his stock must be to furnish a definite number of multiples, or how many multiples can be cut from a given length of stock. The ten tables cover multiples up to 50 in number from 1 to 60 inches in length, including common fractions down to 1/64-inch. The booklet also gives the compositions of a number of steels being manufactured by the company.

ALLOYS (STEEL)—Lukens Steel Co., Coatesville, Pa., is distributing a booklet which gives specifications for chrome-manganese-silicon alloy steel boiler plate. The booklet gives a most complete picture of the materials.

BEARINGS—New Departure Mfg. Co., Bristol, Conn., is distributing a booklet on its line of self-sealed, self-lubricated ball bearings. Some of these bearings have single felt seals, some of them double seals, and some are sealed on one side and shielded on the other.

CAST PARTS—The use of Meehanite metal in the construction of dies, examples of dies made from this material and similar information is covered by a new bulletin, No. 3, of Meehanite Research institute, Pittsburgh.

DRIVES—Short center leather belt drives are presented in a recent folder of Chicago Belting Co., Chicago, which gives a complete description of the drives, and blueprints of installations.

DRIVES—Streamlined motorized speed reducers are covered in a data sheet of Janette Mfg. Co., Chicago, which gives the construction of the units, features, capacities and sizes.

INSTRUMENTS—Small size, low resistance pyrometers that are accurate for all commercial purposes and rugged enough to withstand the severe conditions encountered in industry are described in a bulletin of Thwing Instrument Co., Philadelphia.

PUMPS—Single and two-stage volute centrifugal pumps, types F and U, are presented in two new bulletins of Worthington Pump & Machinery Corp., Harrison, N. J. The bulletin gives specifications and dimensions of the pumps.

PUMPS—Fairbanks, Morse & Co., Chicago, is distributing bulletin No. 5550 on its built-together motor-pump unit. The unit consists of a centrifugal pump, with its enclosed bronze impeller, mounted directly on the shaft of a splash-proof motor.

SHAPES—Cold finished steel and its applications in the design of automobiles are covered in a recent bulletin of Union Drawn Steel Co., Massillon, O.

TUBING—Weights per lineal foot of length for all sizes of hot finished and cold drawn tubing having an outside diameter of from 1/16-inch up to 10¾ inches and a wall thickness varying from 38 B.W.G. up to 1⅝ inches are given in the new series of "Master Weight Tables" prepared by Timken Steel & Tube Co., Canton, O. All gages, wall thicknesses and diameters are given in both common fractions and decimal equivalents.

WELDED PARTS AND EQUIPMENT—Linde Air Products Co., New York, is distributing a booklet on "Recommended Practices for Gas Cutting of Structural Steel" which presents an authoritative treatment of this subject. Another new booklet of the company is a completely revised edition of "Precautions and Safe Practices" which treats the storage, care and handling of oxyacetylene welding and cutting equipment.

Research Publications

Effects of McQuaid-Ehn Grain Size on the Structure and Properties of S. A. E. 1040 Steel. The demand of consumers have made necessary extensive investigations by steel makers in order to determine the properties of controlled steels and adapt them to their consumers' use. Progress has been made to such an extent that, with a knowledge of a consumers' processes and requirements, a steel can be furnished which will be the optimum for the purpose, unless the metallurgist is hampered by obsolete or unreasonably close chemical or physical specifications which were arrived at by empirical means. Published by Carnegie Steel Co., Pittsburg. 16 pp.

High Speed Belt Drives, by C. A. Norman. High speed belt drives have either very small pulleys or very high belt speeds. In the former case it is of importance to ascertain the influence of stiffness on contact angle and idling loss; in the latter a critical scrutiny of the influence of centrifugal force is called for. A theory of the centrifugal force, originated in Germany, shows that the theory current in America is merely an approximation, which under certain circumstances seriously overestimates the influence of centrifugal force on shaft pull. Particularly important is the fact that this is true when the belt is slack and the speed is high. In this study, the German formula is rederived and expanded to cover influence of belt stiffness and varying shaft distance. Also, a formula is derived for the influence of stiffness on contact angle. Both the centrifugal force formula and the stiffness formula are checked experimentally. Tests on idling losses show these to be comparatively more serious for V-belts than for flat cord belts. On small pulleys, particularly at reduced load, the idling losses may result in a comparatively low efficiency for V-belts. These can be run quite slack, however, while the flat cord belts must be run very tight to transmit a power commensurate with their cord strength. Published as engineering experiment station bulletin No. 83 by Ohio State University, Columbus, O. 31 pp. 25c.

MACHINES*

of all types are designed by Executives and Engineers who read Machine Design

Adding machines
Addressing and mailing machines
Agricultural machinery
Aircraft
Bakers' machinery
Baling presses
Blowers and fans
Bookbinding machinery
Bottling machinery
Calculating machines
Canning machinery
Card-punching and tabulating machines
Cars and trucks
Cash registers
Cement and concrete machinery
Change making machines
Check writing machines
Clay working machinery
Clothes pressing machines
Coffee roasting and grinding machines
Condensers
Confectionery and ice cream machinery
Conveying machinery
Cotton gins
Cranes, including hoists and derricks
Dairy machinery
Dish washing machinery
Dredging and excavating machinery
Electrical machinery
Elevators and elevator machinery
Engines, steam and internal combustion
Fare registers and boxes
Flour mill and grain mill machinery
Foundry machinery
Gas machines
Gas regulators
Glass making machinery
Hat-making machinery
Hydraulic machinery
Incandescent lamp making machinery
Laundry machinery
Lawn mowers
Leather working machinery
Locomotives
Machine tools
Manifolding machines
Metal working machinery
Meters, gas and water
Mining machinery
Miscellaneous and special machinery
Motion picture cameras and projector
Motorcycles and bicycles
Motor vehicles
Oil-mill machinery
Oil-well machinery
Ore crushers
Packaging machines
Packing house machinery
Paint making machinery
Paper box machinery
Paper mill and pulp mill machinery
Pharmaceutical machinery
Photo-engraving machinery
Pneumatic machinery
Printing machinery
Pumps and pumping machinery
Refrigerating and ice making machinery
Road making machinery
Rolling mill machinery
Rubber working machinery
Scales and balances
Sewing machines
Shoe machinery
Slicing machines
Slot vending machines
Stokers, mechanical
Stone working machinery
Sugar mill machinery
Textile machinery
Tobacco manufacturing machinery
Transmission machinery
Typewriters
Vacuum cleaners
Washing machines, ironing machines
Welding machines
Well-drilling machinery
Windmills and towers
Woodworking machinery

***Machines as classified by the United States Census Bureau**

PUMPS FOR

COOLING
and
LUBRICATING

Roper Coolant Pumps . . . all types . . . handle cutting compounds and lubricating fluids on metal working machines with a high degree of efficiency. They are non-pulsating and supply ample force to reach the deepest cuts and bores. Guaranteed not to lose prime . . . high or low pressure, delivering 1 to 20 G.P.M.

Roper Coolant Pumps can be designed as an integral part of your machine. Write for Bulletin No. R4MD.

"Dependable Pumps Since 1857"

GEO. D. ROPER CORP., ROCKFORD, ILL.

ALL PURPOSES

THE HEART OF POWER

ROPER PUMPS

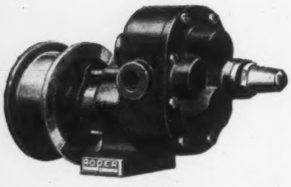


Fig. 1850

Books in Popular Demand

The Engineer's Sketch Book
By Thomas W. Barber $4.50

Kinematics of Machines
By George L. Guillet $3.00

Plastic Molding
By Louis F. Rahm $3.00

Inventions, Patents and Trade-Marks
By Milton Wright $2.50

Book of Stainless Steels
Edited by Ernest E. Thum $5.00

Procedure Handbook of Arc Welding Design and Practice
Published by Lincoln Electric Co. $1.50

Add 15c for postage

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MACHINE DESIGN
Penton Building, Cleveland, Ohio

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INDEX TO ADVERTISERS

Alemite Corp. .... *
Allen-Bradley Co. ....Inside Front Cover
Allis Chalmers Mfg. Co. 49
American Steel & Wire Co. 10

Baldor Electric Co. .... *
Baldwin-Duckworth Chain Corp. 57
Bristol Co. .... *
Brown & Sharpe Mfg. Co. 70
Bruning, Charles, Co., Inc. 68

Carboloy Co., Inc. 69
Carnegie Steel Co. 14
Century Electric Co. 55
Chicago Rawhide Mfg. Co. 4
Climax Molybdenum Co. 9
Cullman Wheel Co. .... *
Cutler-Hammer, Inc. 61

Diehl Manufacturing Co. 8
Dietzgen, Eugene, Co. 67
Dings Magnetic Separator Co. .... *
Dumore Co. 66

Emerson Electric Co. 11

Fafnir Bearing Co. 74
Fairbanks, Morse & Co. .... *
Foote Bros. Gear & Machine Co. 51

Garlock Packing Co. .... *
General Electric Co. 65

Hyatt Roller Bearing Co. .... *

Illinois Steel Co. 59
International Nickel Co. .... *

Janette Mfg. Co. 70

Laminated Shim Co., Inc. 66
Lincoln Electric Co. ....Inside Back Cover
Linde Air Products Co. 63
Link-Belt Co. 3

Magnetic Mfg. Co. .... *
Marsh, Jas. P., Corp. .... *
Morse Chain Co. 53

New Departure Manufacturing Co. 6
New Jersey Zinc Co. .... *
Norma-Hoffmann Bearings Corp. 64

Reeves Pulley Co. 13
Roper, Geo. D., Corp. 72

Shakeproof Lock Washer Co. .... *
Signal Electric Mfg. Co. .... *

Timken Roller Bearing Co. ....Back Cover
Twin Disc Clutch Co. .... *

Union Carbide & Carbon Corp. 63

Viking Pump Co. 68

Wagner Electric Corp. .... *
Whitney Manufacturing Co. .... *

*Advertisements appear in previous issues.

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MACHINE DESIGN is a monthly technical publication conceived, edited and directed expressly for those executives and engineers responsible for the creation and improvement of machines built for sale, and for the selection of the materials and parts to be used.

BUSINESS ANNOUNCEMENTS AND SALES BRIEFS

LINK-BELT CO., Chicago, has purchased the physical assets of Bailey-Burruss Mfg. Co., 1116 Murphy avenue, Atlanta, Ga. All divisions of Link-Belt's Atlanta sales offices are being moved to the Bailey-Burruss plant which will henceforth be known as the Atlanta plant of Link-Belt Co. The new combined operations will be headed by I. H. Barbee, who has been transferred from the Philadelphia plant of the company.

* * *

Timken Roller Bearing Co., Canton, O., has appointed Whitley B. Moore as general manager of the industrial division. Since 1930 Mr. Moore has been sales manager of the company.

* * *

Robert L. Nutt Jr. recently was appointed sales representative in the southeastern district for American Bolt & Nut Fastener Co., Pittsburgh, with headquarters in the National Bank of Commerce building, Norfolk, Va.

* * *

District offices of the development and research department of International Nickel Co. Inc., have been moved into larger quarters in the General Motors building, Detroit. E. J. Hergenroether is district repesentative.

* * *

L. H. Gilmer Co., Tacony, Philadelphia, has announced the appointment of Earl V. Snyder as district manager for New York state, excepting the New York city area, for its line of industrial belts and belting for power transmission.

* * *

Thomas T. Watson, who joined the metallurgical department of Lukens Steel Co., Coatesville, Pa., in August, 1931, has been appointed development and service metallurgist for the company. He will be engaged principally in service and sales work in connection with nickel-clad steel.

* * *

Noble R. Patterson, who for the last eleven years has been associated with International Harvester Co., at its Fort Wayne plant, has joined the organization of Aluminum Industries Inc., Cincinnati, manufacturer of Permite products, as sales engineer.

* * *

Edgar N. Dollin, formerly president of Allied and Acme Die Casting corporations, has formed a new corporation which will be known as the Dollin Corp. to take over the die casting division of American Type Founders Co., and the die casting division of Lionel Corp. Associated with Mr. Dollin will be J. L. Cowen and Mario Caruso. William Gebauer, formerly chief engineer and production manager of Allied Die Casting Corp., will hold a similar position with the Dollin company. The new corporation will be located at Sager Place, Irvington, N. J.

* * *

Sidney Langston has been appointed representative in charge of the Cleveland territory by Ex-Cell-O Aircraft & Tool Corp., Detroit. Offices will be located in the Penton building, 1213 West Third street.

* * *

L. M. Klinedinst has been elected to the board and promoted to the office of vice president in charge of sales for Timken Roller Bearing Co. to fill the vacancy created by the recent resignation of Judd W. Spray.

* * *

Link-Belt Co., Chicago, has acquired the manufacturing and sales rights to the Modern Coal burner, formerly held by Modern Coal Burner Co., a subsidiary of Peabody Coal Co.

* * *

Henry J. Linn Co., 250 Stuart street, Boston, has been appointed New England sales agents for Globe Steel Tubes Co., Milwaukee, manufacturer of seamless steel tubular products, including mechanical tubing and stainless steel tubing.

* * *

Norman F. Tisdale recently has become associated with Molybdenum Corp. of America, Grant building, Pittsburgh. Mr. Tisdale formerly was connected with Republic Steel Corp. at Buffalo and more recently with Titanium Alloy Mfg. Co. in Buffalo.

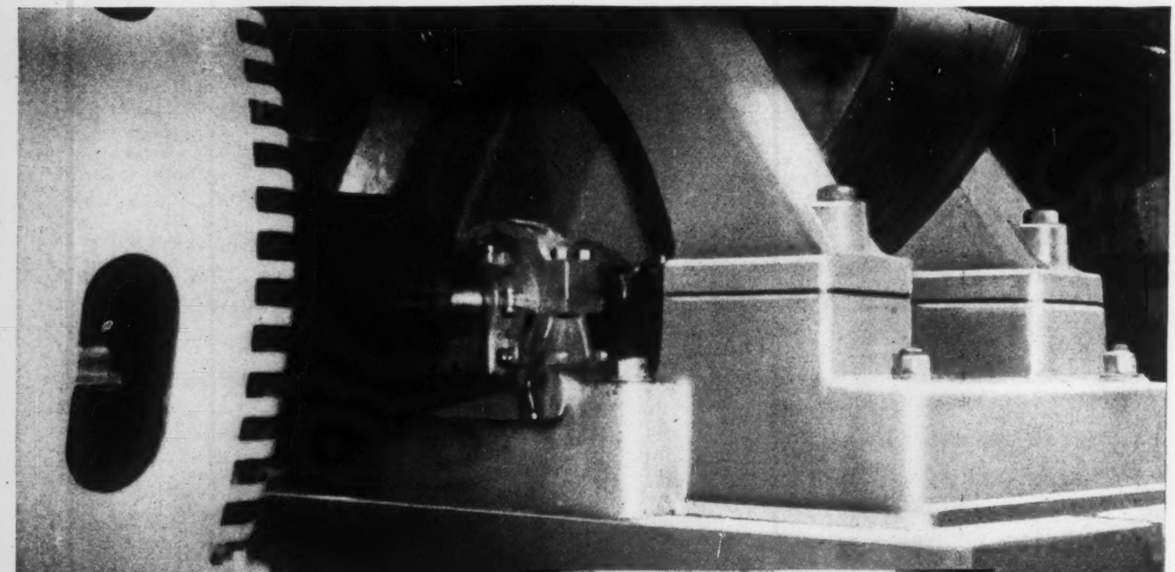
* * *

Charles E. Stuart, president and treasurer of Tyson Roller Bearing Co., Massillon, O., manufacturer of cageless tapered roller bearings, has resigned these positions. Mr. Stuart will remain on the board of directors of the company. Russell E. Colgate, who has been chairman of the board, has been elected president and treasurer succeeding Mr. Stuart. George C. McMullen is vice president in charge of sales.

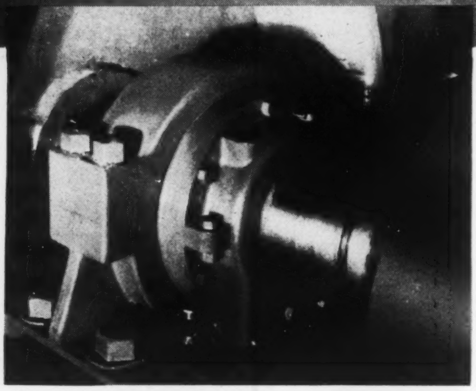
* * *

N. E. Philpot, manager of the Chicago office of Duriron Co., Dayton, O., for several years, has assumed charge of the New York office succeeding W. E. Pratt resigned. Col. M. W. Smith, formerly manager at Buffalo for the company, will be in charge of the Chicago office. W. A. Watkins has been transferred from the general sales office at Dayton to Buffalo as manager. M. L. Bettcher, formerly general superintendent for the Duriron company, has been appointed general manager, succeeding Dudley H. Miller who becomes executive vice president.

Friction Fighting BRUTES



Rubber Grinding Mill Drive employing special double cage assembly, $6\frac{5}{16}$" bore Fafnir Roller Bearing Pillow Block

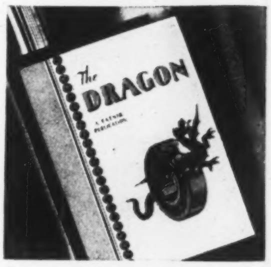


For the Tough Jobs

700 H.P. at 600 r.p.m. is the job assigned to these Fafnir Roller Bearing Pillow Blocks in a rubber grinding mill. It's typical of the installations which are occurring with increasing frequency—applications where the power savings which anti-friction bearings can deliver mount into large figures—where dependability is vital — where compact design is all-important. Fafnir Heavy Duty Industrial Roller Bearings are the economical answer.

In the illustrated application 40% to 50% was saved in power consumption, much more in lubrication costs, and Fafnir Roller Bearings practically eliminated the ever-present bearing breakdown problem despite the severe over-loads which frequently occur.

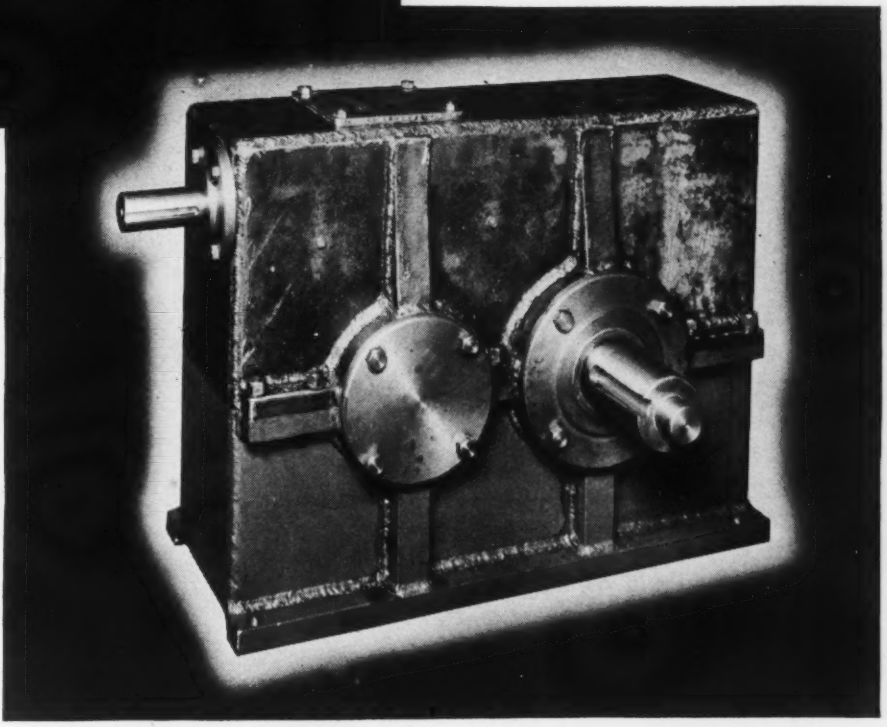
Fafnir offers a comprehensive line of heavy duty industrial roller bearings. Write for complete information. THE FAFNIR BEARING COMPANY, *New Britain, Conn.* Atlanta . . . Chicago . . . Cleveland . . . Dallas . . . Detroit . . . Milwaukee . . . Minneapolis . . . New York . . . Philadelphia.



News of the anti-friction bearing progress is the basis of every issue of "The Dragon." Let us add your name to the mailing list.

FAFNIR BALL BEARINGS

A CASE



OF REDUCTION

in time and cost by "Shield-Arc" welding

Tuesday . . . a failure of the original cast case of this speed reducer shut down an entire manufacturing process. A week to ten days for a new pattern plus added days for casting a stronger case, reported the equipment manufacturer.

In 40 hours half a ton of rolled steel plates and shapes were cut to size, assembled and "*Shield-Arc*" welded to form a stronger, stiffer speed reducer housing at a cost far less than a casting.

Friday . . . production was resumed.

This is but one of hundreds of typical cases of time and money saved, as well as product improvement, effected by "*Shield-Arc*" welded steel construction of machines and machinery parts.

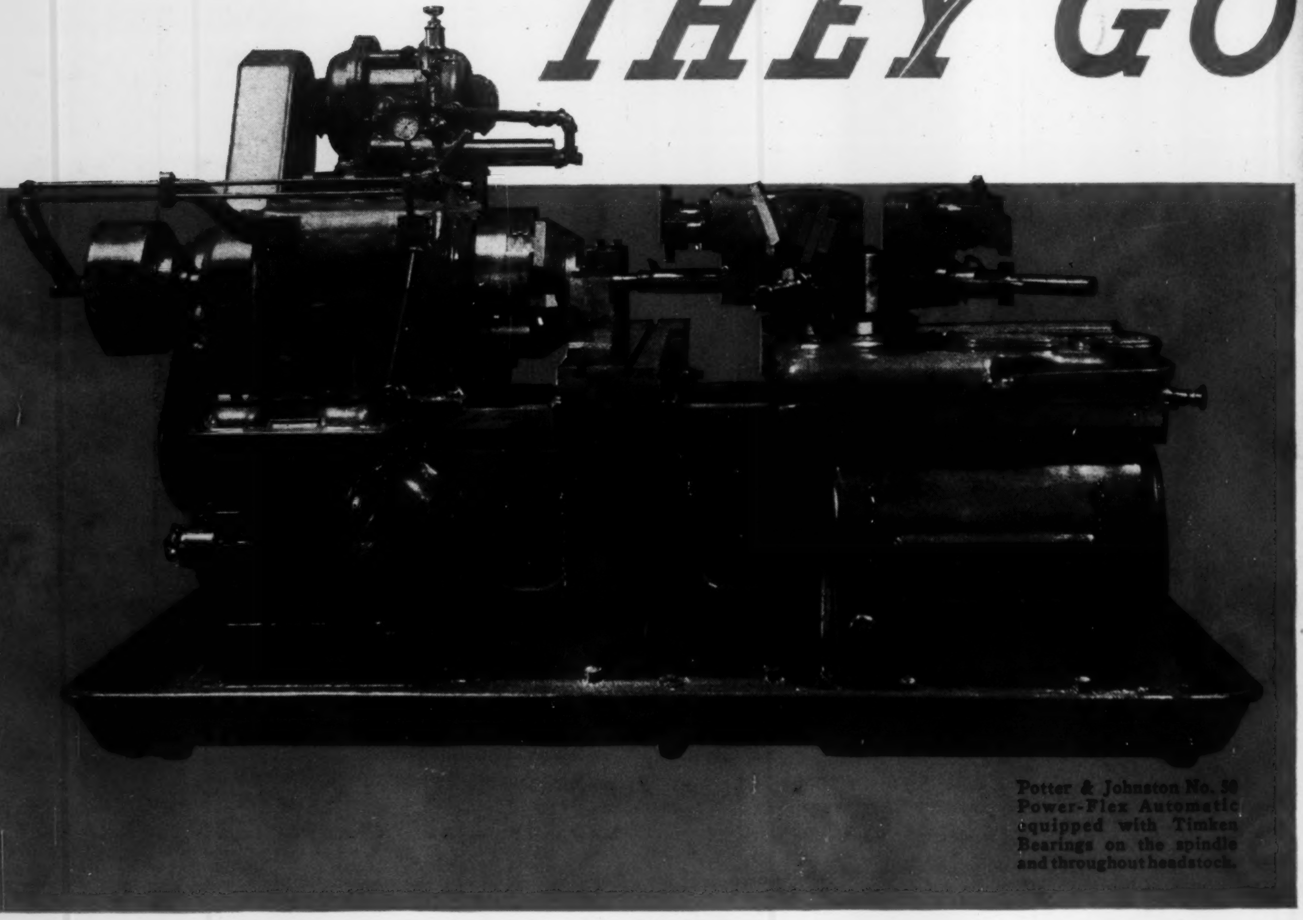
The speed reducer manufacturer, like many other machinery builders, took advantage of every possible saving by welding with a "*Shield-Arc*" welder. It allowed him to get the most out of welding—for "*Shield-Arc*" welds faster. Makes better welds. Uses less power. Puts more of the electrode into the weld.

Eleven distinctive features of the "*Shield-Arc*" welder make it give you more weld per dollar . . . and better welds. That's why more Lincoln welders are in use today than any other make. And why many are scrapping their old type machines for "*Shield-Arcs.*" Find out how much "*Shield-Arc*" welders can save you. Ask The Lincoln Electric Company, Cleveland, Ohio. Largest Manufacturers of Arc Welding Equipment in the World.

W-89

LINCOLN "SHIELD-ARC" WELDERS

ON AND ON THEY GO



Potter & Johnston No. 50 Power-Flex Automatic equipped with Timken Bearings on the spindle and throughout headstock.

ON and on . . . Timken Bearing Equipped spindles . . . turning swiftly, smoothly, chatterlessly . . . meeting every modern challenge as machining tolerances are tightened; production schedules increased; and costs scrutinized more carefully than ever before.

Preloaded or not, as operating conditions may require, Timken Bearings assure unmatched spindle rigidity and freedom from vibration at all speeds, feeds and cutting depths.

They keep the spindle free from wear and protect it against radial, thrust and combined loads. They reduce power consumption to a minimum.

With over 95% of all new heavy duty machine spindles going on Timkens, users have a wide range of choice in makes when buying new equipment. Specify Timken-equipped.

Tapered Roller
TIMKEN BEARING
EQUIPPED

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**